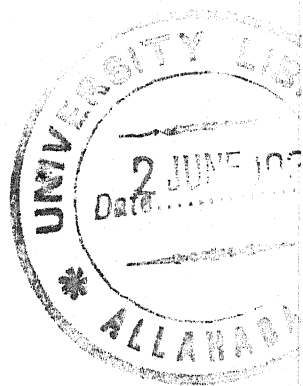


CONTRIBUTIONS TO PALAEOLOGY

FOSSIL FLORAS OF YELLOWSTONE NATIONAL  
PARK AND SOUTHEASTERN OREGON



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#### LIST OF PAPERS

- I. Fossil Floras of Yellowstone National Park. Part I. Coniferous Woods of Lamar River Flora. By Charles B. Read. Pages 1 to 19 and 6 plates.
- II. The Trout Creek Flora of Southeastern Oregon. By Harry D. MacGinitie. Pages 21 to 68 and 16 plates.





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I

FOSSIL FLORAS OF YELLOWSTONE NATIONAL PARK

Part I. Coniferous Woods of Lamar River Flora

By CHARLES B. READ

With six plates.

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## Part I. Coniferous Woods of Lamar River Flora

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### INTRODUCTION

The purpose of the series of papers, of which this is the first, is to consider the fossil floras of the Yellowstone National Park. Considerable time has lapsed and many collections have been made since the floras were monographed by Knowlton;<sup>1</sup> therefore it seems desirable to reconsider them. Likewise, the recent advances in ligneous anatomy make a revision even more necessary.

Mention of the fossil forests of the Yellowstone is first met in the reports of the Hayden Survey for the year of 1878, when a geologic reconnaissance of the Park was made under the direction of W. H. Holmes.<sup>2</sup> The record mentions the occurrence of great quantities of fossil wood in the vicinity of Junction Butte and in the cliffs on the sides of the valley of the "East Fork of the Yellowstone" or Lamar River. Concerning the great thickness of volcanic breccia measured in a section on the face of Amethyst Mountain, Holmes<sup>3</sup> writes—

"These strata rest upon the unevenly eroded strata of the paleozoic and granite rocks, and form a great part of the mountain ranges which enclose the valley. They are horizontal and apparently conformable throughout the entire thickness of 5000 feet. The greater part of this immense group of strata is filled with the silicified remains of ancient forests."

Holmes distinguished between the two widespread series of eruptives, the early acid and the early basic volcanics, recording the silicified woods as occurring in the latter.

The next scientific observations on the fossil plants were made by J. Felix in 1896,<sup>4</sup> the result of a short stay at Yancey's in the park. A number of species of fossil wood was described in a short paper, inadequately illustrated—a common fault of the early papers on the subject. Four dicotyledonous and two coniferous woods were discussed. The greatest contribution of this work is the interesting comparison of stem and root wood. Platen<sup>5</sup> has more recently published a short paper on this material, in which the nature of the fossils is clearly demonstrated.

<sup>1</sup> F. H. Knowlton, U. S. Geol. Surv. Mon. 32, pt. 2, 651-882, pls. 77-121, 1899.

<sup>2</sup> W. H. Holmes, U. S. Geol. and Geog. Surv. Territories of Wyoming and Idaho, pt. 2, 47-52, 1878.

<sup>3</sup> W. H. Holmes, U. S. Geol. and Geog. Surv. Territories of Wyoming and Idaho, pt. 2, 48-49, 1878.

<sup>4</sup> J. Felix, Zeitschr. Deutsch. d. Geol. Gesell., 249-260, Jahr. 1896.

<sup>5</sup> P. Platen, *Prometheus*, vol. 20, 241-246, 1909.

The only detailed taxonomic treatment of the Tertiary floras of the Park is Knowlton's monograph.<sup>1</sup> In this paper about one hundred and fifty species are described from three distinct horizons. Several woods are considered, and among them three of coniferous nature. Of these, two are from the Lamar River flora and one from the Intermediate flora<sup>2</sup> of Crescent Hill. Here, as in Felix' paper, the descriptions are inadequate. Great difficulty is encountered in their application.

In connection with this work, the accompanying reports of several members of the United States Geological Survey must be mentioned.<sup>3</sup> Included in the volume with the account of the flora is a series of papers dealing with the geology and paleontology of the Park area. W. H. Weed,<sup>4</sup> in a preliminary paper, discusses the stratigraphy of the southern end of the Snowy Range and mentions the sections exposed at various places in the Lamar Valley; likewise, accounts of the fossil forests are to be found in the Yellowstone National Park<sup>5</sup> and Absaroka Folios.<sup>6</sup>

Only a few statements of contributing value have been made since Knowlton's paper. Platen's<sup>7</sup> revision has been mentioned. Both Penhallow<sup>8</sup> and Seward<sup>9</sup> have commented on the occurrence and woods to the extent of regarding the species of pine similar or identical. Stopes<sup>10</sup> mentions these in her paper on the flora of the Lower Greensand. A popular paper published by the Park Service<sup>11</sup> is likewise available.

### ACKNOWLEDGMENTS

The field and laboratory studies which form the bases for this and succeeding papers have been made possible through the financial assistance of the Carnegie Institution of Washington. To Dr. R. W. Chaney of that Institution, the writer is greatly indebted, not only for advice and encouragement, but also for the working facilities which have been so generously provided. Mr. H. L. Mason, of the University of California, has contributed many valuable suggestions during the course of the work, and his untiring interest in the field work has added much to the collections.

<sup>1</sup> Arnold Hague and Associates, U. S. Geol. Survey Mon. 32, pt. 2, 1-893, pls. 1-121, 1899.

<sup>2</sup> F. H. Knowlton, U. S. Geol. Survey, Mon. 32, pt. 2, 347, 1899.

<sup>3</sup> Arnold Hague and Associates, U. S. Geol. Surv., Mon. 32, pt. 2, 1899.

<sup>4</sup> W. H. Weed, U. S. Geol. Survey, Mon. 32, pt. 2, 203-212, 1899.

<sup>5</sup> Arnold Hague, W. H. Weed, J. P. Iddings, U. S. Geol. Survey, Folio 30, 1896.

<sup>6</sup> Arnold Hague, U. S. Geol. Survey, Folio 52, 1899.

<sup>7</sup> P. Platen, *Prometheus*, vol. 20, 241-246, 1909.

<sup>8</sup> D. P. Penhallow, *Manual of North American Gymnosperms*, pages 227, 346-347, 1907.

<sup>9</sup> A. C. Seward, *Fossil Plants*, vol. 4, pages 347-348, 1919.

<sup>10</sup> M. C. Stopes, *Catalogue of Mesozoic Plants: The Cretaceous Flora*, pt. 2, pages 77, 102-103, 1915.

<sup>11</sup> F. H. Knowlton, *Fossil Forests of the Yellowstone National Park*, Gov. Printing Office, 1914.

The type slides of the woods described by Dr. Knowlton have been made available through the courtesy of Dr. Roland W. Brown of the United States Geological Survey.

To the officials of the National Park Service and in particular to Horace M. Albright, R. W. Toll, Dorr G. Yeger and E. N. Jones the writer wishes to express appreciation for the many kindnesses and courtesies extended while in the Park.

John Bauman of the Tower Falls Ranger Station has contributed greatly. His intimate knowledge of the area studied has been of utmost value in the reconnaissance.

### GENERAL CONSIDERATIONS

The plant-bearing series of early basic breccias outcrops over a wide area in the northeast corner of the Park. Here the woods and leaves of the Lamar River flora occur in intercalated layers of silts and tuffs throughout most of the section, which measures 5000 feet in certain localities. Silicified woods are often so abundant as to afford a convenient index to the strata.

It is not the purpose of this paper to discuss the age and correlation of this flora in detail; not enough field work has been done to justify an elaborate treatment of that phase of the problem, yet some preliminary statement of the writer's point of view seems both necessary and desirable. Knowlton<sup>1</sup> has pointed out the affinities between the flora of the Older Basic Breccias and that of the Auriferous Gravels of California, this being the basis for the establishment of the age of the Yellowstone flora as Upper Miocene. Recent work has shown that the Auriferous Gravels flora is in need of revision. With regard to this flora, Chaney<sup>2</sup> has stated that—

“During the past ten years evidence has accumulated which indicates that the Auriferous Gravels contain several distinct floras in horizons ranging from Eocene to Miocene.”

Of these, the flora most similar to the Lamar River assemblage is tentatively regarded as Eocene, although more data must be accumulated to conclusively demonstrate this age reference. It is significant, however, that many of the species in question are known from definitely recognized Eocene horizons in other regions, and several of them are found in the large Fort Union flora.

Two hundred and fifty miles northwest of the Park near the town of Missoula, Montana, the occurrence of a typical redwood association of Bridge Creek age in deposits of lacustrine origin has been recorded.<sup>3</sup> This is quite critical in a consideration of the age of the

<sup>1</sup> F. H. Knowlton, U. S. Geol. Survey Mon. 32, pt. 2, 790, 1899.

<sup>2</sup> R. W. Chaney, Written communication, 1930.

<sup>3</sup> O. E. Jennings, Mem. Carnegie Mus., vol. 8, No. 2, 385-450, pls. 22-33, 1920.

Lamar River flora, since it establishes the presence of an association of plants of known age at a point within the Rocky Mountains and not far removed from the area covered by the early basic breccias. Similar, although less complete floras, occur at other stations in the

TABLE 1.—*Distribution of Tertiary plants of Lamar River flora of Yellowstone National Park.*<sup>1</sup>

Species	In Park			Outside Park					
	Lamar River	Intermediate	Fort Union	Laramie	Denver and Livingston	Fort Union	Green River	Auriferous Gravels	Undifferentiated Eocene of British Columbia
<i>Asplenium iddingsi</i> .....	X		X						
<i>Osmunda affinis</i> .....	X				X				
<i>Lygodium kaulfussii</i> .....	X		X				X		X
<i>Equisetum canaliculatum</i> .....	X	X	X						
<i>Equisetum deciduum</i> .....	X		X						
<i>Taxites olriki</i> .....	X		X					X	X
<i>Sequoia langsdorffii</i> .....	X	X	X	X		X	X	X	X
<i>Juglans californica</i> .....	X							X	
<i>Juglans crescentia</i> .....	X		X						
<i>Juglans rugosa</i> .....	X		X	X	X		X	X	X
<i>Hicoria antiqua</i> .....	X					X			
<i>Populus balsamoides</i> .....	X							X	X
<i>Salix varians</i> .....	X						X	X	X
<i>Salix angusta</i> .....	X				X		X	X	
<i>Salix elongata</i> .....	X						X		
<i>Corylus macquarryi</i> .....	X				X	X	X		X
<i>Castanea pulchella</i> .....	X		X						
<i>Quercus furcinervis</i> .....	X							X	
<i>Ulmus pseudofulva</i> .....	X					X			
<i>Ulmus minima</i> .....		X				X			
<i>Planera longifolia</i> .....	X				X		X		
<i>Ficus shastensis</i> .....	X							X	
<i>Ficus sordida</i> .....	X							X	
<i>Ficus densiflora</i> .....	X		X						
<i>Ficus asiminifolia</i> .....	X		X					X	
<i>Magnolia californica</i> .....	X							X	
<i>Magnolia pollardi</i> .....	X		X						
<i>Laurus primigenia</i> .....	X		X						
<i>Laurus californica</i> .....	X		X					X	
<i>Laurus grandis</i> .....	X		X					X	
<i>Persea pseudocarolinensis</i> .....	X							X	
<i>Malopenna lamarensis</i> .....	X		X						
<i>Platanus guillelmæ</i> .....	X		X	X	X	X	X		
<i>Rhus mixta</i> .....	X							X	
<i>Elæodendron polymor-</i> <i>phum</i> .....	X	X				X			
<i>Sapindus affinis</i> .....	?	X	X			X			
<i>Sapindus wardii</i> .....	X		X						
<i>Rhamnus rectinervis</i> .....	X			X	X				
<i>Aralia notata</i> .....	X	X	X		X	X		X	
<i>Aralia whitneyi</i> .....	X							X	

<sup>1</sup> Revision may show that some of these old references are incorrect generically, but for correlation purposes the present determinations suffice.

Rockies, notably at Florissant, Colorado, where an excellent flora is well known.<sup>1</sup> The Lamar River flora is also a redwood association, but differs from the great Middle Tertiary redwood forests of western America in the presence of a large number of species common in definitely known Eocene horizons not yet reported from younger strata. These are listed with their distribution.

The conclusion to be drawn seems obvious. The Lamar River flora contains certain elements which can be accounted for only by regarding the assemblage as somewhat older than Miocene. Such a setting back of the age of the early basic breccias is not out of accord with the views expressed by others. Cockerell,<sup>2</sup> as early as 1909, questioned the Miocene reference of this flora, and remarked—

"The conclusion seems legitimate that the Yellowstone Intermediate and Lamar floras are Upper Eocene or at least older than Miocene. Were they really Miocene, with so much resemblance to even the basal Eocene, the Florissant flora, to get as far on the side as its lack of affinity would suggest, would have to be projected somewhere into the future."

Jones and Field<sup>3</sup> have arrived at a similar conclusion as to the age of the breccias, employing an entirely different line of reasoning. Their study of the geologic history of the Grand Canyon of the Yellowstone has suggested that the ages of the Tertiary volcanics must be set back to allow time for the complex series of events which have taken place. They state that—

"The plants from the later or basic breccias are regarded, however, as belonging to the base of the Neocene period. In view of the erosional history of the Park, it is open to question whether even the latest of the breccias are as young as the Neocene."

Tentatively the view is taken that the Lamar River flora is Upper Eocene or Lower Oligocene in age, but more conclusive discussion of the subject is reserved for detailed treatment in a future paper.

Materials collected during the field season of 1929, as well as those of previous expeditions examined, indicate the presence of four species of coniferous woods in the Lamar River flora. Ample confirmation of this is found in the nature of leaf impressions and occasional cones which occur at many of the localities, associated with the petrifications.

In Knowlton's monograph<sup>4</sup> are described three coniferous woods: *Sequoia magnifica*, *Pityoxylon alderisoni* and *P. amethystinum*. A

<sup>1</sup> F. H. Knowlton, Proc. U. S. Nat. Museum, vol. 51, 241-296, 1916.

<sup>2</sup> T. D. A. Cockerell, Amer. Nat., vol. 44, 31-47, 1910.

<sup>3</sup> O. T. Jones and R. M. Field, Amer. Jour. Sci., 5th ser., vol. 17, 260-278.

<sup>4</sup> F. H. Knowlton, U. S. Geol. Survey Mon. 32, pt. 2, 755-765, 1899.

question has been brought up by several students of wood structure concerning the separation of the latter two. It has been found impossible to regard them as other than identical and synonymous with *P. fallax* described by Felix<sup>1</sup> and figured by Platen.<sup>2</sup>

*Sequoia magnifica* is based on types now in the National Museum. The slides are all cut from stem wood, probably from the main axis. Few lateral branches of this species are observed in the deposits. The matrix in which the petrifications are embedded commonly contains numerous impressions of leafy twigs referable only to *Sequoia*. These were called *Sequoia langsdorfi* by Knowlton,<sup>3</sup> in accordance with the prevalent custom of applying different specific names to different organs preserved, unless actual connection was demonstrated. Certain cone-like structures were also referred to *Sequoia*. Thus abundant evidence for the presence of the genus *Sequoia* is found in the deposits.

The types of *Pityoxylon alderi* and *P. amethystinum* have been likewise secured from the National Museum. Material of these synonymous species is common over the whole of the area studied. Fascicles of needles are occasional and Knowlton<sup>4</sup> has listed several species. Impressions of parts of cones are recorded from several localities.

In this connection, the interesting cone, *Pinus premurrayana*,<sup>5</sup> from a station east of Yellowstone Lake may be mentioned. Knowlton has discussed it and comments on the remarkable preservation. Its close simulation of *Pinus murrayana*, now the most abundant conifer in the Park, suggested to him that this might not be a fossil but a modern cone. Since the region immediately east of the lake contains numerous hot-spring basins, it seems reasonable to suppose that silicification might take place in a comparatively short time, the waters often being highly charged with silica. It suffices to state that the fossil status of this cone must be regarded with question until further field work can make clear the occurrence.

In several localities in which collections were made, a type of coniferous wood quite different from any of those already recorded was observed. This material shows certain characteristics which identify it with the *Cupressinoxylon* type; others which suggest its taxaceous affinity. Leafy twigs referable to the genus *Torreya* occur in deposits closely associated and afford additional evidence of the presence of some member of this family.

<sup>1</sup> J. Felix, Zeitschr. deutsch. d. Geol. Gesell., 118-119, Jahr. 1896.

<sup>2</sup> P. Platen, *Prometheus*, vol. 20, 241-246, 1909.

<sup>3</sup> F. H. Knowlton, U. S. Geol. Survey Mon. 32, pt. 2, 682-683, 1899.

<sup>4</sup> F. H. Knowlton, U. S. Geol. Survey Mon. 32, pt. 2, 679-680, 1899.

<sup>5</sup> F. H. Knowlton, U. S. Geol. Survey Mon. 32, pt. 2, 677-678, 1899.



## PRESERVATION OF THE WOODS

Numerous writers have commented on the phenomena attending petrification of woods. St. John<sup>1</sup> has reviewed the literature on this subject, and has regarded petrified woods as falling into three categories with the characteristics which are listed below:

"1. Infiltration of mineral matter into the cell cavities, and the intercellular spaces, with the vegetable tissue preserved.

"2. Complete replacement of the plant tissues, but this may be due to the spaces being filled first, and later the tissues being replaced. (Differential replacement.)

"3. Complete replacement of portions of the mass and filling only of cavities in other parts."

While studying the woods of the Lamar River flora, it became apparent that woods falling into all of these classes were present. Additional observations were made on the preservation of the woods. Two fundamental types and their intergradations have been met with, namely those of infiltration and differential replacement. Miss St. John's third type is regarded as a combination of these, and can not be considered as distinct. It is rather common in the woods collected. Another type of preservation, also an intermediate, is recognized in certain small branches of roots and in fragments from larger branches and roots. In these a leaching of the carbonaceous materials has taken place in specimens which were formerly infiltrated only. Such woods are quite friable and are undesirable for sectioning. On large trunks a zone of this wood is found in the outer portions. Obviously this is a condition prior to differential replacement, but is distinct in that it has taken place at a rather late date, probably since the wood has reached the zone of weathering.

Occurring in the tuffs and breccias with the woods are numerous cylindrical masses of chalcedony. Some of these may be ascribed to inorganic origin, but others can only be regarded as products of complete replacement of wood. The shape strongly suggests this, and the presence of infiltrated wood containing irregular areas totally replaced by chalcedony may be advanced as further proof of this process, in such cases in intermediate phases.

With few exceptions the wood studied is silicified. These exceptions refer to material partly or wholly calcareous.

Infiltrated woods are the most valuable for anatomical work. Such woods are jet black and must be ground to extreme thinness before they can be studied, but they usually show much more detail than woods in which replacement has followed infiltration. These latter, while they may show the grosser structures excellently, in most cases lack a fine preservation of pitting.

<sup>1</sup> R. N. St. John, *Econ. Geol.*, vol. 22, 729-739, 1927.

## SUMMARY

The Lamar River flora of Yellowstone National Park occurs throughout a series of beccias 5000 feet thick in places. The flora is of a transitional type, showing on the one hand a marked resemblance to certain early Eocene floras of Western America and on the other to well-known Middle Tertiary floras. It must be regarded as much older than the Upper Miocene to which it has been referred—either Lower Oligocene or Upper Eocene. Four species of coniferous woods are recognized in the flora, these generally identical with forms growing in the modern redwood forests.

## TAXONOMY OF THE WOODS

A survey of the literature on the subject shows a heterogeneity of ideas concerning the diagnostic data which must be assembled to describe woods accurately. Difficulty in comparisons has been encountered, due to varying degrees of importance placed on features of the wood. Kraus,<sup>1</sup> Gothan,<sup>2</sup> Penhallow,<sup>3</sup> Jeffrey,<sup>4</sup> Bailey,<sup>5</sup> Holden,<sup>6</sup> Torrey,<sup>7</sup> and a host of others have commented on the relative values of the various tissues of the wood for systematic purposes. Torrey<sup>8</sup> has compiled a table of data which is of particular value since it enables the writer to diagnose materials in a concise but accurate manner. With modifications, his method has been adopted in this paper. The table of data is as follows:

*Annual Rings*—Present or absent; regular or irregular in contour; early wood as compared with late wood; transition from early to late wood; width of rings; compactness of early and late wood.

*Resin Canals*—Present or absent; normal or traumatic; horizontal or vertical or both; size and shape; secretory cells as to size, shape, thickness of walls, number of rows; thyloses.

*Wood Rays*—Seriation; height and variability; shape of cells in cross-section; attitude of terminal walls; pitting of lateral, terminal, and upper and lower walls with reference to number, size and character; irregular thickenings of walls; ray tracheids, with reference to distribution, type of pitting and thickenings of walls; resin.

*Wood Parenchyma*—Terminal or diffuse; abundant or scarce; distribution; contents; size.

<sup>1</sup> G. Kraus, Schimper's *Traité de Paléontologie Végétale*, vol. 2, 363-385, 1870-1872.

<sup>2</sup> W. Gothan, Preuss. Geol. Landesanstalt und Bergakademie, Berlin, new series, pt. 44, 108 pages, 1905; Kungl. Svenska Vet.-Akad. Handl., Stockholm, vol. 42, No. 10, 1-44, pl. 1, 1907; vol. 45, No. 8, 1-56, pl. 1-7, 1910.

<sup>3</sup> D. P. Penhallow, *Manual of North American Gymnosperms*, 1907.

<sup>4</sup> E. C. Jeffrey, *Anatomy of Woody Plants*, 317-356, 1917.

<sup>5</sup> I. W. Bailey, Bot. Gaz., vol. 48, 47-55, pl. 5, 1909.

<sup>6</sup> Ruth Holden, Proc. Amer. Acad. Arts and Sci., vol. 48, 609-623, 1913.

<sup>7</sup> R. E. Torrey, Bot. Gaz., vol. 58, 168-177, 1914; Mem. Boston Soc. Nat. Hist. vol. 6, No. 2, 41-106, pls. 8-15, 1923.

<sup>8</sup> R. E. Torrey, Mem. Boston Soc. Nat. Hist., vol. 6, No. 2, 56-58, 1923.

*Tracheids*—Variation in size; bars of Sanio; pitting, with reference to distribution of pits in radial and tangential walls and in various parts of the ring; nature of pits; spiral thickenings; resinous tracheids; thyloses.

*Medulla*—Size; sclerotic cells; resinous structures.

## NOMENCLATURE

It has been the custom to describe fossil woods and designate them with the ending, *-oxylon*, even when evidence has been available to suggest that these were referable to modern genera. Notable exceptions occur, however. For instance, fossil woods of sequoian affinities are usually placed in the genus *Sequoia* rather than *Sequoioxylon*, even though pines from the same horizons are called *Pityoxyla*. Such an irregular system is confusing. To the writer it seems only logical to regard associated woods and leaves as the same species when there is morphological evidence to demonstrate the point. It is held that actual continuity is not necessary in the cases of Tertiary plants, which bear close resemblance to living species, to establish this. In this paper the policy adopted is to refer those woods whose affinity to modern forms is clear to their respective genera without the *-oxylon* termination. Materials of uncertain affinity and those which can be identified no further than the family are placed in genera terminated with the customary suffix.

## TRIBE ABIETINEÆ

### Genus PINUS (Tourn.) Linne

*Annual Rings*—Present, usually distinct, variable.

*Resin Canals*—Present, normal in both directions, usually large, the secretory cells thin walled.

*Wood Ray*—Linear ones uniseriate, in the later types with marginal and interspersed tracheids, ray tracheids reticulate, dentate, or smooth walled; pitting usually on all walls, both of ray tracheids and ray parenchyma, in the latter the pits simple or slightly bordered and modified into large oopores. Resin common in rays.

*Wood Parenchyma*—Absent.

*Tracheids*—Bars of Sanio present, pitting uniseriate or multiseriate, when the latter, opposite; pits chiefly confined to the radial walls, but in some species on the tangential walls of the late wood.

### *Pinus baumani* new species

*Annual Rings*—Well marked, late wood dense, the transition abrupt; diameter of tracheids in early wood averaging 58  $\mu$ .

*Resin Canals*—Present in both directions, the vertical with one or occasionally two rows of thin-walled secretory cells; the horizontal canals in

fusiform rays slightly attenuated; vertical canals not abundant, confined chiefly to the latter half of the ring of growth.

*Wood Rays*—Few to 20 cells high, chiefly 6 to 10; ray tracheids marginal or interspersed, rays often constricted near these interspersions, sparingly dentate, heavily pitted on all walls; parenchyma pitted on all walls, the lateral medium sized and of the opopore or slightly bordered type, 2 to 4 per tracheid field. The whole ray with a narrow and linear aspect due to the oblong to oval shape of the elements as viewed in tangential section.

*Wood Parenchyma*—Absent.

*Tracheids*—Pitting chiefly uniseriate, bars of Sanio present.

*Medulla*—Not observed.

A number of specimens of this wood are at hand. In all cases the annual rings are well developed, and an abrupt transition between the early and late wood is observable. The resin canals occur sparingly and are confined with few exceptions to the latter half of the ring. One of the most noticeable contrasts between this wood and that of *P. fallax* is found in the number of resin ducts present. The rays are chiefly low, and the constituents show narrow and oblong lumens when viewed in tangential aspect. They are typically pinoid of the section *Scleropitys*.<sup>1</sup> Marginal tracheids are present and show a poorly preserved dentate condition. The parenchyma of the rays likewise is characteristic of the genus, pits being of the opopore or slightly bordered types. The tracheids show pits chiefly in one row and separated by well-marked bars of Sanio. The fusiform rays, which are not abundant, are narrow and slightly attenuate.

This wood is typical of the hard pine group, showing not only the dense late wood indicative of that section, but likewise the characteristic ray tracheids. Attempts to compare it with previously described species have met with little success so far as the fossil forms are concerned. Among the modern pines affinity to a number is suggested, but no indications of specific identity have been observed in the material examined. With the Cretaceous and Eocene woods of the Atlantic seaboard<sup>2</sup> no great affinity is suggested. *Pityoxylon peali*<sup>3</sup> from the nearby Upper Gallitin Basin seems similar to this fossil in many respects. Since these deposits were not visited during the 1929 reconnaissance, no materials of this species are available for comparison. The illustrations accompanying the original description are not sufficient to verify any determination.

*Occurrence*—Fossil Forest, Specimen Ridge.

*Collection*—Univ. Calif. Col. Pal. Bot. No. 1278; slides 1278 a-f.

In Plate 3, figures 1 and 6, and plate 6, figure 2, are transverse sections which show the abrupt transition from early to late wood. The resin ducts are not nearly so numerous as in *P. fallax*.

In plate 3, figures 3 and 5 are sections showing the appearance of the wood in radial view. Figure 3 shows some of the details of the tracheid pitting. In figures 2 and 4 the fusiform rays appear less attenuate than is the case in *P. fallax*. The elements composing the rays are oblong to oval.

<sup>1</sup> I. W. Bailey, Amer. Nat., vol. 44, 284-293, 1910; E. C. Jeffrey and M. A. Chrysler, Bot. Gaz., vol. 42, 4, 1906.

<sup>2</sup> E. C. Jeffrey and M. A. Chrysler, Bot. Gaz., vol. 42, 1-14, 1906; Ruth Holden, Proc. Amer. Acad. Arts and Sci., vol. 48, 609-623, 1913; I. W. Bailey, Annals Bot., vol. 25, 315-325, 1911.

<sup>3</sup> F. H. Knowlton, Bull. Torr. Bot. Club, vol. 23, 251, pl. 271, 1896.

*Pinus fallax* (Felix) new combination

*Pityoxylon fallax* Felix, Zeitschr. Deutschr. d. Geol. Gesell., 254, Jahr. 1896.

*Pityoxylon aldersoni* Knowlton, U. S. Geol. Surv. Mon. 32, pt. 2, 763, 1898.

*Pityoxylon amethystinum* Knowlton, U. S. Geol. Surv. Mon. 32, pt. 2, 764, 1898.

*Annual Rings*—Well marked, characteristically wide, the transition from early to late wood gradual, late wood forming an indeterminate zone as a result of transition; average diameter of early wood tracheids about 45  $\mu$ .

*Resin Canals*—Present in both directions; large, numerous, scattered throughout the whole ring; chiefly single but occasionally in pairs or threes, then fused laterally; secretory cells in one or two rows, thin walled; thyloses not observed; horizontal ducts smaller than vertical, in narrow, attenuate fusiform rays.

*Wood Rays*—Chiefly uniseriate, except those bearing resin canals; few to 18 cells in height, chiefly low; cells broadly oval as viewed in tangential section; tracheids of rays marginal and abundantly pitted; parenchyma with several large oopores per cross field, typically abietinean.

*Wood Parenchyma*—Absent.

*Tracheids*—Pitting of the pinean type, pits in 1 or 2 series; when the latter, they are opposite.

*Medulla*—Large, sclerotic.

Several writers have commented on the similarity of *P. aldersoni* to *P. amethystinum*. Penhallow<sup>1</sup> was inclined to regard them as identical. A study of the material recently collected, as well as the slides of the type material, has convinced the writer that separation is impossible. Further, it becomes necessary to place these species in synonymy with *P. fallax* (Felix), the nature of which is known as result of a restudy of the slides by Platen.<sup>2</sup>

While the material available does not compare in excellency of preservation with the other species of pine described in this paper, the fossil is so interesting as to merit a full discussion. The unusually broad rings of growth and the abundance of resin canals, which are often present throughout the whole of the annual increment, give the wood a very characteristic appearance. The structure is open and the transition gradual. Low, uniseriate rays made up of elements which appear oval or even broadly angular in tangential section distinguish this wood from *P. baumani*; likewise the occasional laterally bulging walls of the parenchyma cells suggest a diagnostic character. The fusiform rays are more attenuate than in the other Yellowstone species. In some respects this fossil bears a resemblance to certain California coastal pines of the closed cone section, possibly superficial, but certainly strengthened by the occurrence with *Sequoia*.

The writer has been fortunate in securing a well-preserved branch of this species. The protoxylem is, of course, endarch; numerous canals abut directly on the primary wood and on the pith in the interfascicular areas. This is regarded as a character of great diagnostic worth in the recognition of members of the group *Scleropitys*,<sup>3</sup> into which this pine is placed.

Among the Tertiary pines, the only one comparable is *Pinus* (*Pityoxylon*) *columbiana*<sup>4</sup> from the Kettle River Oligocene deposits. As described, the general habit of growth suggested by the rings is the same. The

<sup>1</sup> D. P. Penhallow, *North American Gymnosperms*, 346-347, 1907.

<sup>2</sup> P. Platen, *Prometheus*, vol. 20, 241-246, 1909.

<sup>3</sup> E. C. Jeffrey and M. A. Chrysler, *Bot. Gaz.*, vol. 42, 4.

<sup>4</sup> D. P. Penhallow, *North American Gymnosperms*, 348, 1907.

height of the rays and the shape of the individual cells likewise afford features of similarity. A comparison of the pitting of the Yellowstone pine with Penhallow's species can not be made, since these details are not even well enough preserved to allow detailed observation. Both species show characters which place them in the *Insignis* or hard-pine group. They differ in the much lower rays and in the presence of resinous parenchyma in large areas surrounding the resin canals—all characteristics of *Pinus columbiana*.

*Occurrence*—Specimen Ridge, Fossil Forest, Yancey Forest, Crescent Hill. This wood is common at most outcrops of the breccia.

*Collection*—U. S. Nat. Mus. Col. Pal. Bot. No. 110-11, 12; 122-24; 131-33; 158-63. Univ. Calif. Col. Pal. Bot. No. 1279; slides 1279, a, b; 1280 a-e.

Plate 2, figures 1 and 2, and plate 5, figures 4 and 6, show the very characteristic appearance of the wood in transverse section, including the abundant resin canals, the gradual transition from early to late wood, and the very wide rings.

Plate 2, figures 3 and 4, show the general appearance of the linear and fusiform rays. Figures 5 and 6 are introduced to show the pitting of the tracheids and the general aspect of the rays. In none of the material examined was there detail of ray pitting.

In plate 6, figure 3, the pith and the primary and adjacent secondary wood are seen. The pith is sclerotic in places and the resin canals are situated almost directly on the metaxylem, suggesting that reference should be made to the section, *Scleropitys*.

## TRIBE TAXODINEÆ

Genus *SEQUOIA* Endl. Syn. Conif. 197. 1847

*Annual Rings*—Present, late wood usually distinct as compared with early wood, transition abrupt; rings rather narrow but variable in width.

*Resin Canals*—Traumatic only, in one or both directions, small vertical canals usually in tangential series, secretory cells with ligneous walls in one or several rows, thyloses commonly present.

*Wood Rays*—Linear rays uniseriate or partly biseriate; ray tracheids absent except when recalled by traumatism; upper and lower walls of ray parenchyma cells thin and rarely pitted, lateral walls with a few pits, these with the orifices slightly bordered or broadened into oopores. Resin commonly present.

*Wood Parenchyma*—Diffuse, not distinctly zonate, abundant, chiefly in early wood, resinous, cells large, prominent.

*Tracheids*—Variable in size in the different parts of the ring; bars of Sanio present; radial walls strongly pitted with bordered pits in one or two rows (occasionally more), opposite in cases of bi- or multi-seriation, tangential walls pitted in the late wood of some species.

### *Sequoia magnifica* Knowlton

*Cupressinoxylon eutretron* Felix, Zeitschr. deutsch. d. Geol. Gesell., 225, Jahr. 1896.<sup>1</sup>

*Sequoia magnifica* Knowlton, U. S. Geol. Survey Mon. 32, pt. 2, 761, 1899.

*Annual Rings*—Well developed, variable but usually narrow, zone of summer wood only a few cells wide, transition abrupt; tracheids of early wood averaging about 64  $\mu$  in diameter.

<sup>1</sup>This reference is made provisionally. Platen has stated that *C. eutretron* seems referable to *Sequoia*, but since no figures have been seen by the writer, no attempt is here

*Resin Canals*—Not observed.

*Wood Rays*—Uniseriate or biseriate in part, height few to 20 cells, chiefly 10 to 16, narrow; terminal and upper walls unmarked; lateral walls with 2 or 3 medium-sized oval oopores per cross field.

*Wood Parenchyma*—Abundant diffuse, or in some cases zonate in the latter half of the ring; filled with drops of resinous secretions; lumens smaller and more flattened than the surrounding tracheids.

*Tracheids*—Variable in size in different parts of the ring; pitting commonly in one row, but occasionally in two, then opposite; bars of Sanio present.

*Medulla*—Not observed.

While the most complete records of fossil *Sequoias* are those of leaves, several woods have been recorded. These are listed below.

TABLE 2—The occurrence of woods of *Sequoia*.

Species	Taramie Creta- ceous	Porcu- pine Creek Eocene	Bear River Eocene	Coch- rane Eocene	Lamar Valley	Auri- ferous Gravel	Cali- fornia Plio- cene	Cali- fornia Pleis- tocene
<i>S. langsdorffii</i> .....	.....	X	?	?	.....	.....	.....	.....
<i>S. burgessii</i> .....	X	X	.....	.....	.....	.....	.....	.....
<i>S. (?) penhallowii</i> .....	.....	.....	.....	.....	.....	X	.....	.....
<i>S. montanense</i> .....	X	.....	.....	.....	.....	.....	.....	.....
<i>S. dakotense</i> .....	X	.....	.....	.....	.....	.....	.....	.....
<i>S. laramiense</i> .....	X	.....	.....	.....	.....	.....	.....	.....
<i>S. magnifica</i> .....	.....	.....	.....	.....	X	.....	.....	.....
<i>S. sempervirens</i> .....	.....	.....	.....	.....	.....	.....	X	X

The oldest authentic record of *Sequoia* wood which has come under the writer's observation is from the Laramie beds of the Rocky Mountain and Great Plains regions.<sup>1</sup> Penhallow<sup>2</sup> has compared *Sequoia burgessii* from these strata with *S. magnifica* and has remarked that—

"*S. burgessii* resembles this fossil in many essential features, but differs from it in the very essential fact that it has conspicuous resin canals in the medullary rays, which Dr. Knowlton . . . states . . . are certainly wanting in *S. magnifica*."

The writer has had occasion to examine a great many specimens of *S. magnifica* and has in no case observed traumatic passages. Torrey<sup>3</sup> recently described a wood attributed to *S. burgessii* from the Laramie of Colorado in which the details of ray pitting are described. A similarity to *S. magnifica* is observed in the number of pits per cross field and their size.

With *Sequoia langsdorffii*, woody remains of which were described by Penhallow<sup>4</sup> from the Great Valley Group of British Columbia, this fossil likewise finds some points of agreement. The sporadic occurrence of resin

<sup>1</sup> R. E. Torrey, Mem. Boston Soc. Nat. Hist., vol. 6, No. 2, 74-80, 1923.

<sup>2</sup> D. P. Penhallow, Royal Soc. Canada, Trans., 2d ser., vol. 9, sec. 4, 42, f. 5-8, 1903.

<sup>3</sup> R. E. Torrey, Mem. Boston Soc. Nat. Hist., vol. 6, No. 2, 79-80, 1923.

<sup>4</sup> D. P. Penhallow, *Manual North American Gymnosperms*, 226, 1907.

canals can not be taken into consideration as a character which allows separation of the two. These are occasional on the outer face of the late wood in *S. langsdorffii*, there probably traumatic. The general aspect of the rays, including the height, seriation and shape of individual cells as viewed in tangential section suggests a strong similarity if not identity. Since the lateral ray pits in *S. langsdorffii* were not seen, the affinity of this wood and its synonymy with other species must remain in doubt.

Returning to the resin ducts, Jeffrey<sup>1</sup> and his students have pointed out that in these older woods there is a striking tendency toward the development of resin canals as the result of traumatic stimuli—much greater than is the case with the later Tertiary and modern *Sequoias*. Much emphasis has been placed on this decreasing tendency as a feature of phylogenetic worth. No evidence of traumatism in the Yellowstone species has been noted in the great quantity of materials which has passed through the writer's hands during the course of the field and laboratory studies.

With regard to the anatomical details of *Sequoia magnifica*, the wood has a distinctly modern aspect. The annual rings show a definite demarcation between the early and late wood, and the resin cells are often confined to the latter half of the ring of growth. In tangential aspect the rays are quite variable in height and show the Sequoian feature of partial biseriation. The pitting of the rays is confined to the lateral walls and is of the small oval opopore type. It is the small number of these per tracheid field which definitely sets this species off from *S. sempervirens*. The tracheids show more common uniseriate than biseriate pitting and, when the latter is the case, the pits are opposite. Bars of Sanio have been observed in well-preserved areas.

In one locality a number of standing stumps still ensheathed in the bark were found. An alternation of thin-walled parenchymatous elements with lenticular masses of thick-walled fibrous cells characterizes this tissue system; manifestly identical with the bark cut off by modern *Sequoias*. Unfortunately the inner portion is entirely replaced by silica and the structure obliterated. In none of the material collected was it possible to observe the cambial cells and their more immediate derivatives—the uncrushed phloem elements.

**Occurrence**—Specimen Ridge, Fossil Forest, Yancey Forest, Crescent Hill. This wood is common at all outcrops of the plant-bearing breccias.

**Collection**—U. S. Nat. Mus. Col. Pal. Bot. No. 143-150; 155-157. Univ. Calif. Col. Pal. Bot. No. 1282; slides 1282 a-d; 1041 a, b.

In plate 1, figures 1 and 2, and plate 6, figure 1, the sharp contrast and the abrupt transition between the early and late wood in the rings of growth characteristic of most *Sequoia* woods can be seen. Scattered throughout the rings, but particularly in the latter half, are numerous resin cells.

The general aspect of the wood in radial section is seen in figure 3 of Plate 1. Figure 5 of Plate 1 and figure 6 of plate 4 show details of the rays and present the pitting of the tracheids. Numerous resin cells are seen in the sections.

In Plate 1, figures 4 and 6, the heights of the rays and their partly biseriate condition are shown in tangential sections. Resinous parenchyma cells are present in these views.

Plate 5, figure 5, is a transverse section of bark and shows the nature of the Sequoian bark found associated with the trunks.

<sup>1</sup> E. C. Jeffrey, Proc. Nat. Acad. Sci. vol. 11, No. 1, 101-105, 1925.



## TRIBE CUPRESSINEÆ

## Genus CUPRESSINOXYLON Goeppert

The genus *Cupressinoxylon* in its present usage includes woods of a number of genera and has been used as a depository for a great many species whose true reference can not be ascertained because of faulty preservation. The general type of *Cupressinoxylon* is conservative and is met with in a number of genera. Consequently it is with extreme difficulty that segregation can be made even in well-preserved material. The diagnosis is as follows:

*Annual Rings*—Present, variable.

*Resin Canals*—Absent.

*Wood rays*—Uniseriate or occasionally biseriate in part, height varying widely, ray cells entirely parenchymatous, pitting mostly on lateral walls, these small and chiefly 1 to 6 per cross field.

*Wood Parenchyma*—Diffuse, extremely variable in quantity and distribution; resinous.

*Tracheids*—Bars of Sanio present, bordered pits usually on the radial walls but in some genera also on the tangential walls in 1 or 2 (occasionally more) rows; when the latter, opposite.

*Cupressinoxylon lamarense*, new species

*Annual Rings*—Distinct, irregular in contour and in width; late wood forming a narrow and dense zone, transition rather gradual except in wounded regions; average diameter of tracheids in early wood of ring 34  $\mu$ .

*Resin Canals*—Absent.

*Wood Rays*—Uniseriate, few to 22 cells in height; pitting confined to the upper and lower and lateral walls, there small oculipores (?); in tangential section the rays narrow, cells oval or slightly oblong, resinous in places.

*Wood Parenchyma*—Occasionally present; then not in any regular arrangement.

*Tracheids*—Pitting seldom observable; apparently uniseriate.

*Medulla*—Not observed.

The material upon which this species is based was obtained from two logs, one in the Yancey Forest<sup>1</sup> and the other on Specimen Ridge.<sup>2</sup> Neither log showed preservation worthy of favorable comment.

The occurrence of masses of wounded tissue has caused the writer to make a careful study of this wood in the hope that the traumatism might suggest the systematic position of the material. This can not be satisfactorily determined by a study of the normal tissues since they are without detail of preservation. The yearly increments show a gradual transition from early to late wood. One of the most noticeable features of the wood is brought out clearly in the transverse section. Depressions in the rings of growth are to be seen at certain points where dense masses of tracheary tissue assume the superficial appearance of aggregated rays. Pronounced discordances of annual rings are likewise present in these areas. The only satisfactory explanation of this condition is that these represent wounded areas; the contour suggests a traumatic reaction to pressure of some sort. A careful study has failed to reveal the presence of canals in the abnormal tissue. This fact is of importance since it immediately eliminates members of the abietinean alliance from the discussion.

<sup>1</sup> "Yancey's Forest" refers to the group of fossil stumps below Lost Lake and approximately one and one-half miles by road from Tower Falls Ranger Station.

<sup>2</sup> Collected in the talus at the base of Specimen Ridge.

In the transverse section there appear numerous cells which bear a resemblance to resinous tissue. Longitudinal sections show that in most instances these are not resin parenchyma cells, but tracheids filled with dark masses of partially decayed ligneous materials which have become detached from the cell walls. Strands of true wood parenchyma occur only infrequently. In the transverse section they may be distinguished by the flattened lumens which are of less radial diameter than the surrounding tracheids.

The rays are normally of less than medium height, and in the traumatic areas they appear low. The individual components are elongate oval; the rays consequently narrow. The discordance of the tracheids is very pronounced in traumatic areas sectioned in the tangential plane. Details of pitting are scarcely discernible. Numerous small pits appear to have been located on the upper and lower as well as on the lateral walls. The tracheids likewise fail to show details, but occasionally traces of uniseriate bordered pits are seen. Other markings which may have been present on the tracheal walls are not preserved.

In a number of respects this wood bears a resemblance to genera of the Taxaceæ. The paucity of resin cells even in the traumatic areas agrees well with the observations of Bliss.<sup>1</sup> Seward<sup>2</sup> states that taxaceous genera can only be separated from *Cupressinoxyla* on the basis of the presence of spiral tracheids in the secondary wood. In this respect, the Lamar Valley wood presents a negative characteristic, but the practical value of this criterion must be modified by the obvious fact that spiral markings can not be expected in other than the best-preserved petrifications.

The reference of this wood to *Cupressinoxylon* must be made on purely anatomical grounds. Its true affinities are open to question, since the wood shows certain characteristics which suggest a taxaceous alliance, an affinity further borne out by the presence in the associated deposits of leafy twigs referable to *Torreya*.

*Occurrence*—Yancey Forest, Specimen Ridge.

*Collection*—Univ. Calif. Col. Pal. Bot. No. 1281; slides 1281 a-g.

Plate 4, figures 1, 2 and 3, and plate 5, figures 1 and 3 show the appearance of the wounded areas as contrasted with the normal wood. No evidences of traumatic ducts can be seen. Many of the cells which suggest resin parenchyma are tracheids which have been filled with material detached from the cell walls.

In Plate 4, figure 5, and plate 5, figure 2, the contrast between wounded and unwounded wood as it occurs in tangential section is seen.

Plate 4, figure 4, shows the general aspects of the radial section.

<sup>1</sup>M. C. Bliss, Bot. Gaz., vol. 66, 54-60, 1918.

<sup>2</sup>A. C. Seward, *Fossil Plants*, vol. 4, 202-203, 1919.

## CONCLUSIONS

1. The woody remains of the Lamar River flora contain four species of conifers. The presence of these is abundantly confirmed by the associated leaf and cone impressions.

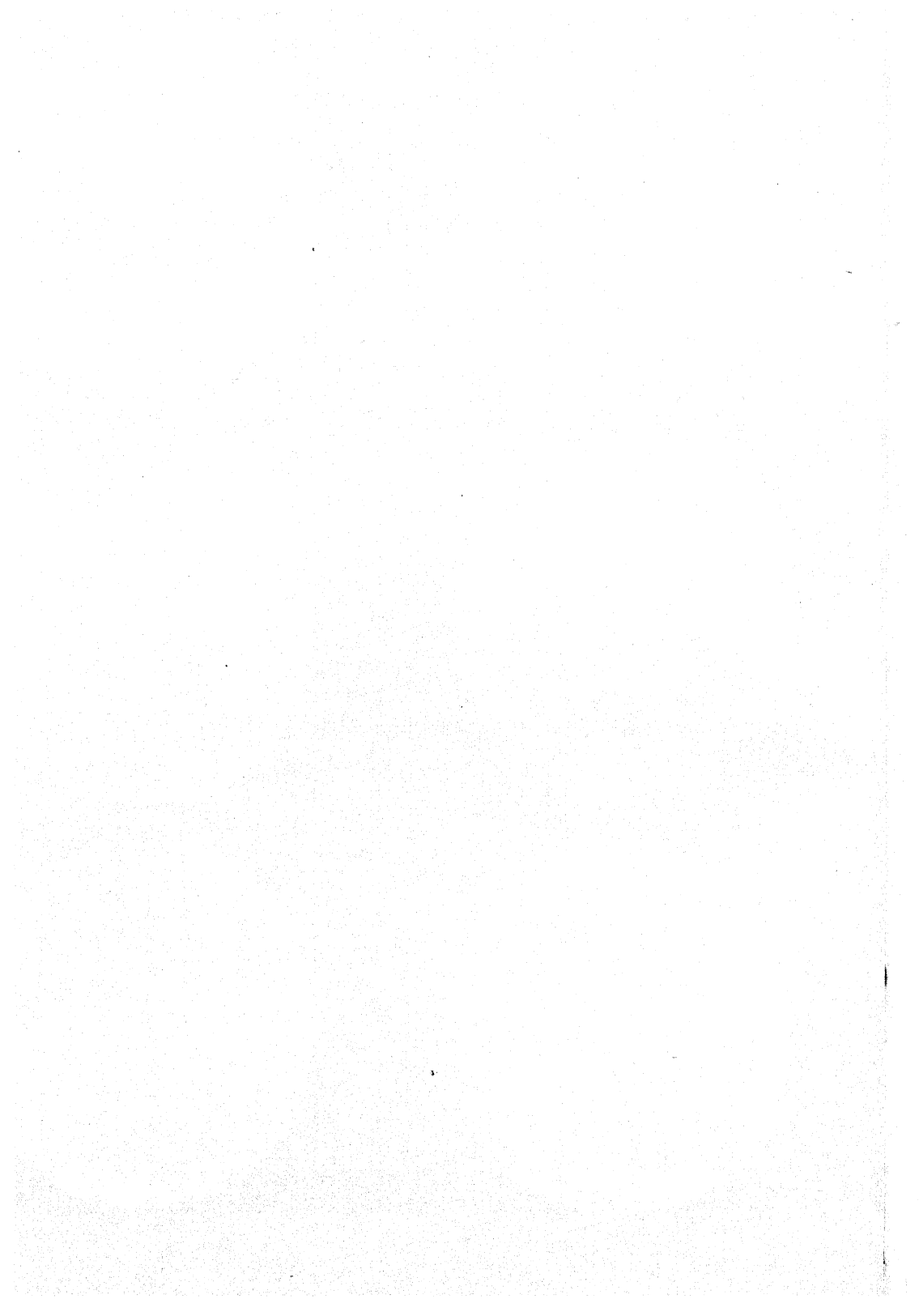
2. *Sequoia magnifica* is characterized by a type of wood which is of a distinctly modern aspect and is closely allied to the present day *Sequoia sempervirens*.

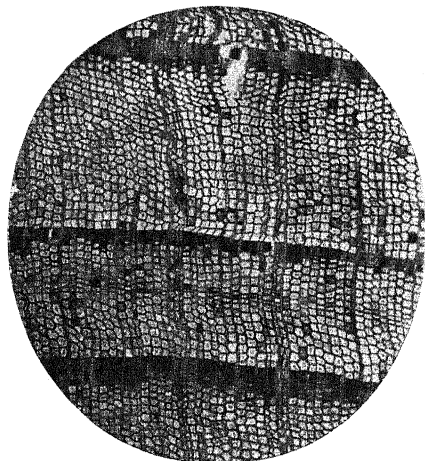
3. Additional proof of the validity of this reference to the genus *Sequoia* is furnished by the presence of bark of the type characteristic of that genus.

4. Two species of the genus *Pinus* are recorded in the flora, *P. baumani* and *P. fallax*. Both are of the section *Scleropitys* as is shown in *P. baumani* by the ray tracheids which bear the characteristic irregularities of the walls, and in *P. fallax* by the presence of resin ducts in several rows in the first ring of growth, the innermost abutting on the primary wood.

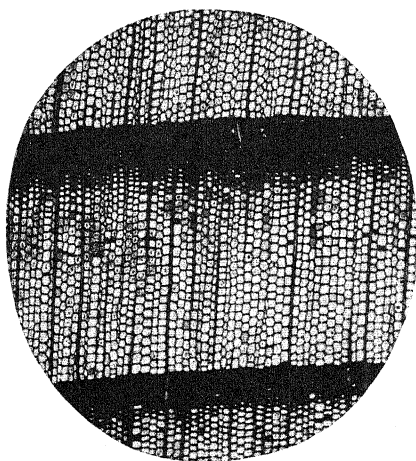
5. These pines are of advanced types and suggest that the genus, in its most restricted definition, was established by Upper Eocene or Lower Oligocene times.

6. *Cupressinoxylon lamarensense* is a wood of the general type of the *Cupressinoxyla*, but the paucity of resin cells even in the wounded areas suggests an affinity to the Taxaceæ. This is further borne out by the presence of leafy twigs in close association which are referable only to *Torreya*.

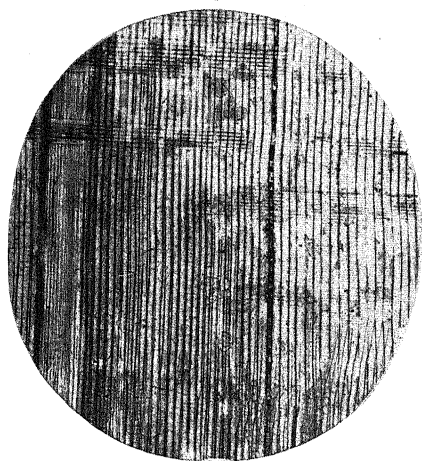




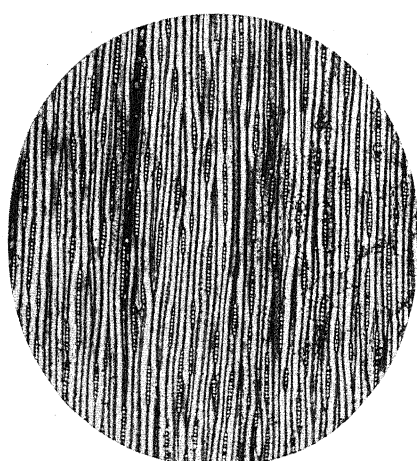
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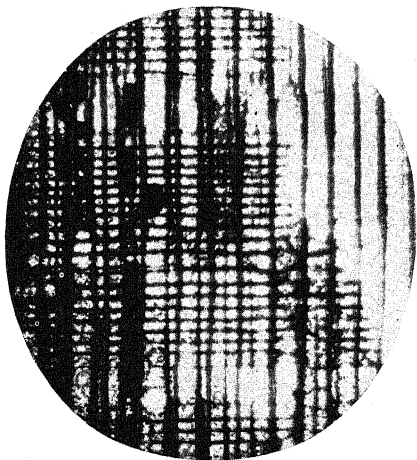
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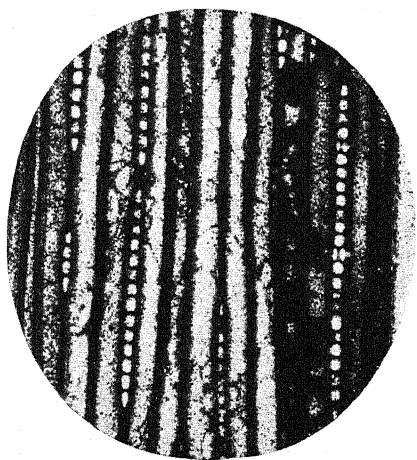
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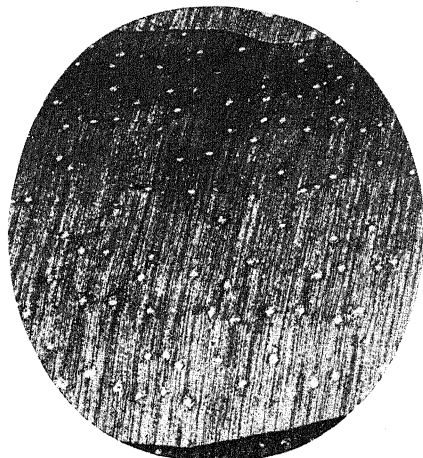
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*Sequoia magnifica*

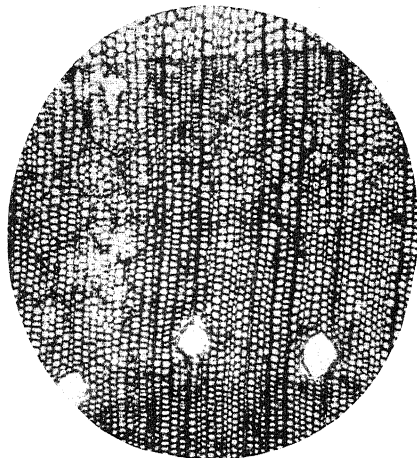
FIG. 1—Transverse section.  $\times 40$ .

FIG. 2—Transverse section.  $\times 40$ .

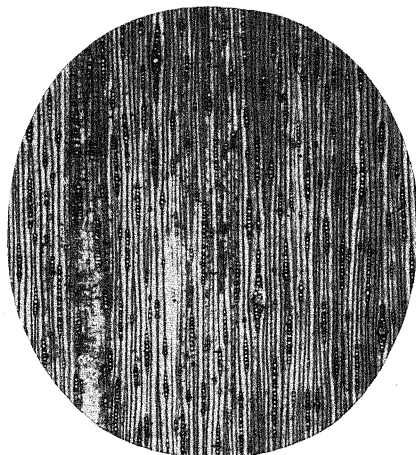




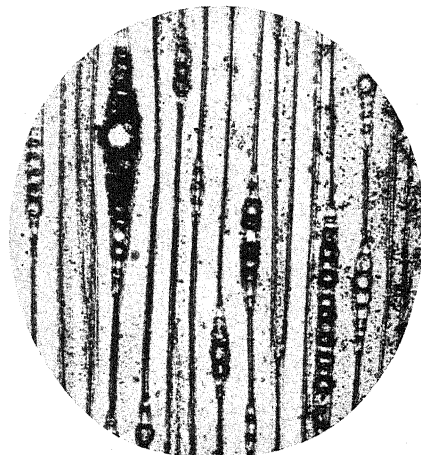
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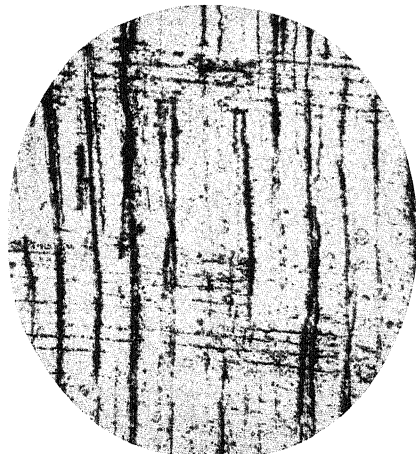
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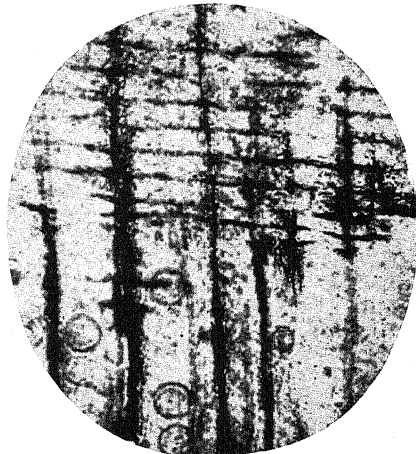
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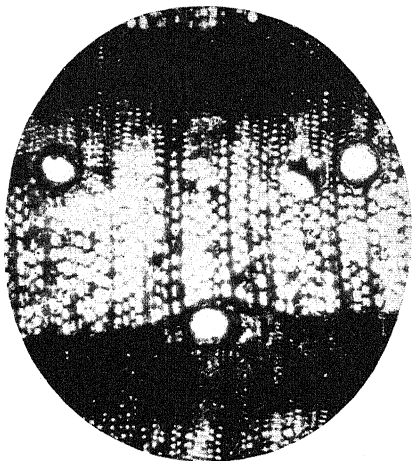
*Pinus fallax*

FIG. 1—Transverse section.  $\times 8$ .

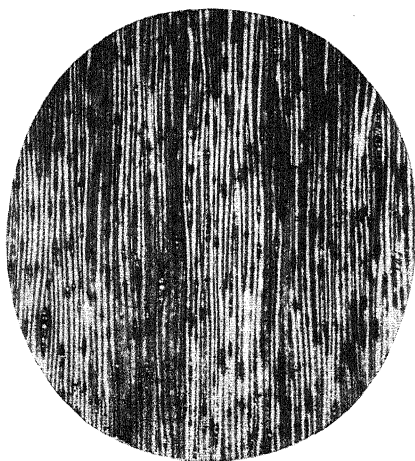
FIG. 2—Transverse section.  $\times 40$ .







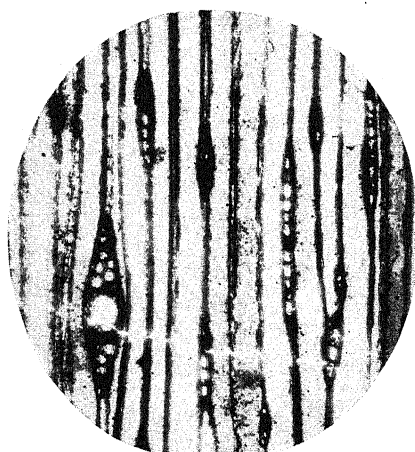
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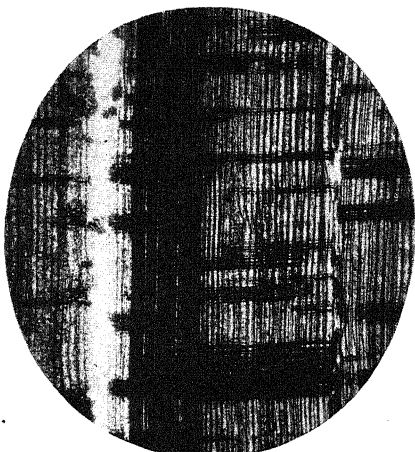
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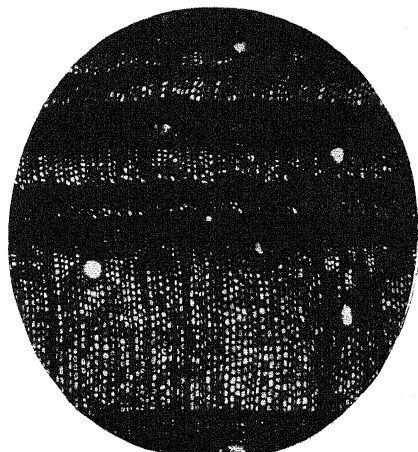
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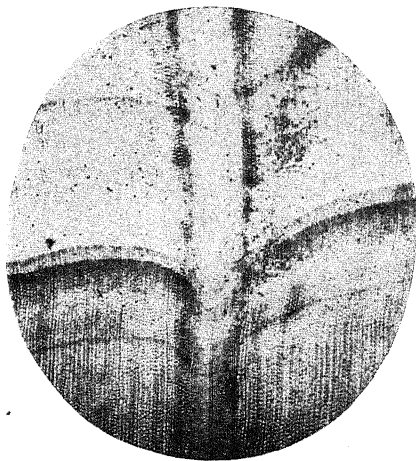
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*Pinus bowanii*

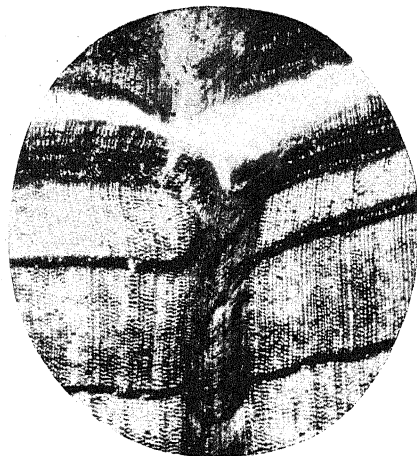
FIG. 1—Transverse section  $\times 80$

FIG. 2—Tangential section  $\times 25$

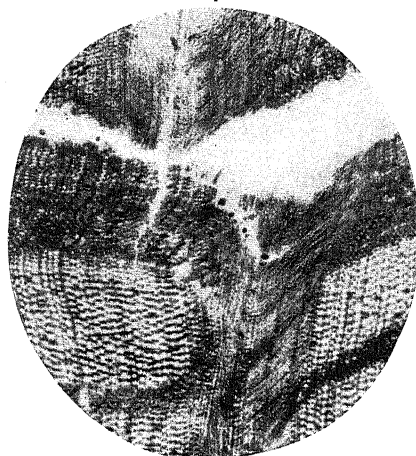




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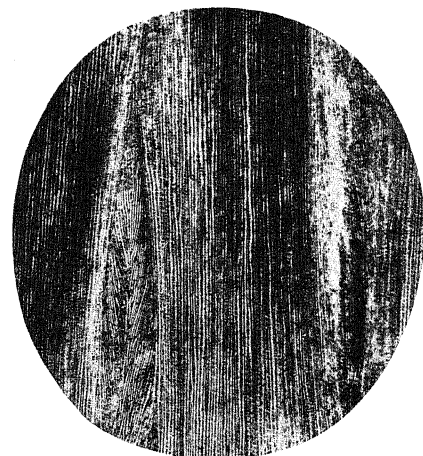
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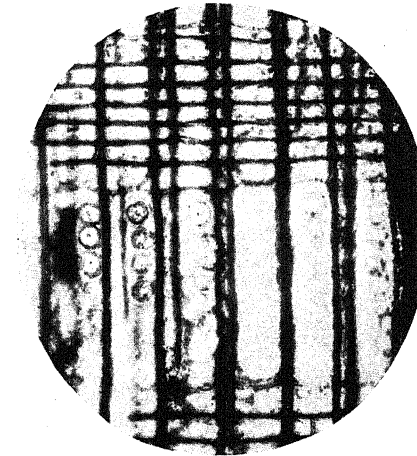
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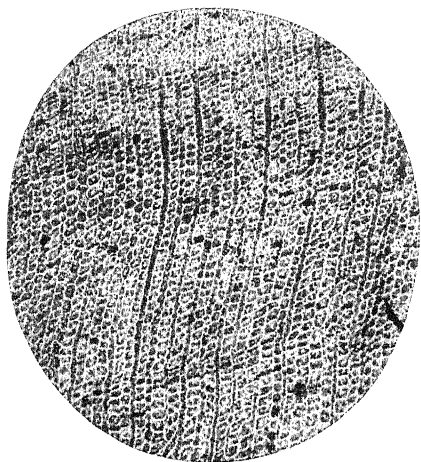
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*Cupassinorxylon lamareuse*

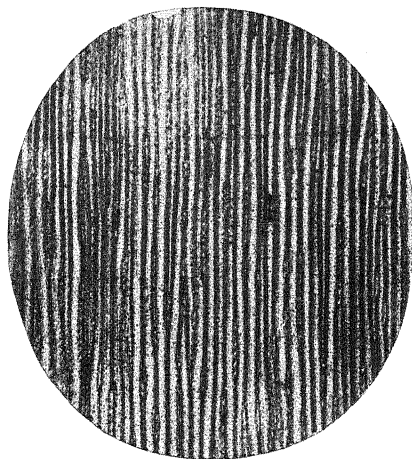
FIG. 1—Transverse section.  $\times 25$ .

FIG. 2—Transverse section.  $\times 25$ .

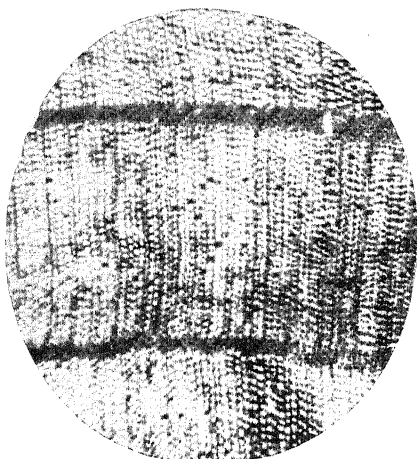




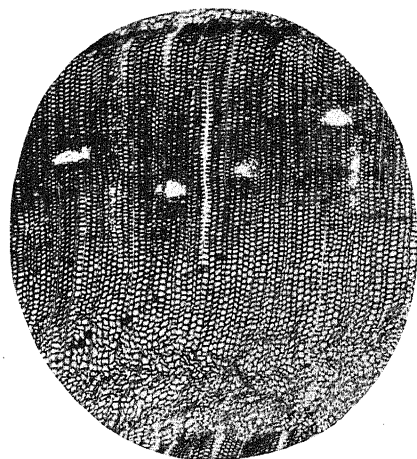
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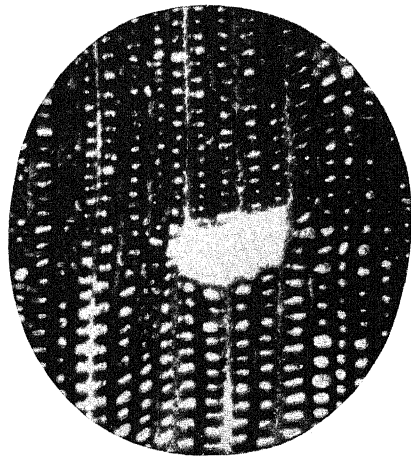
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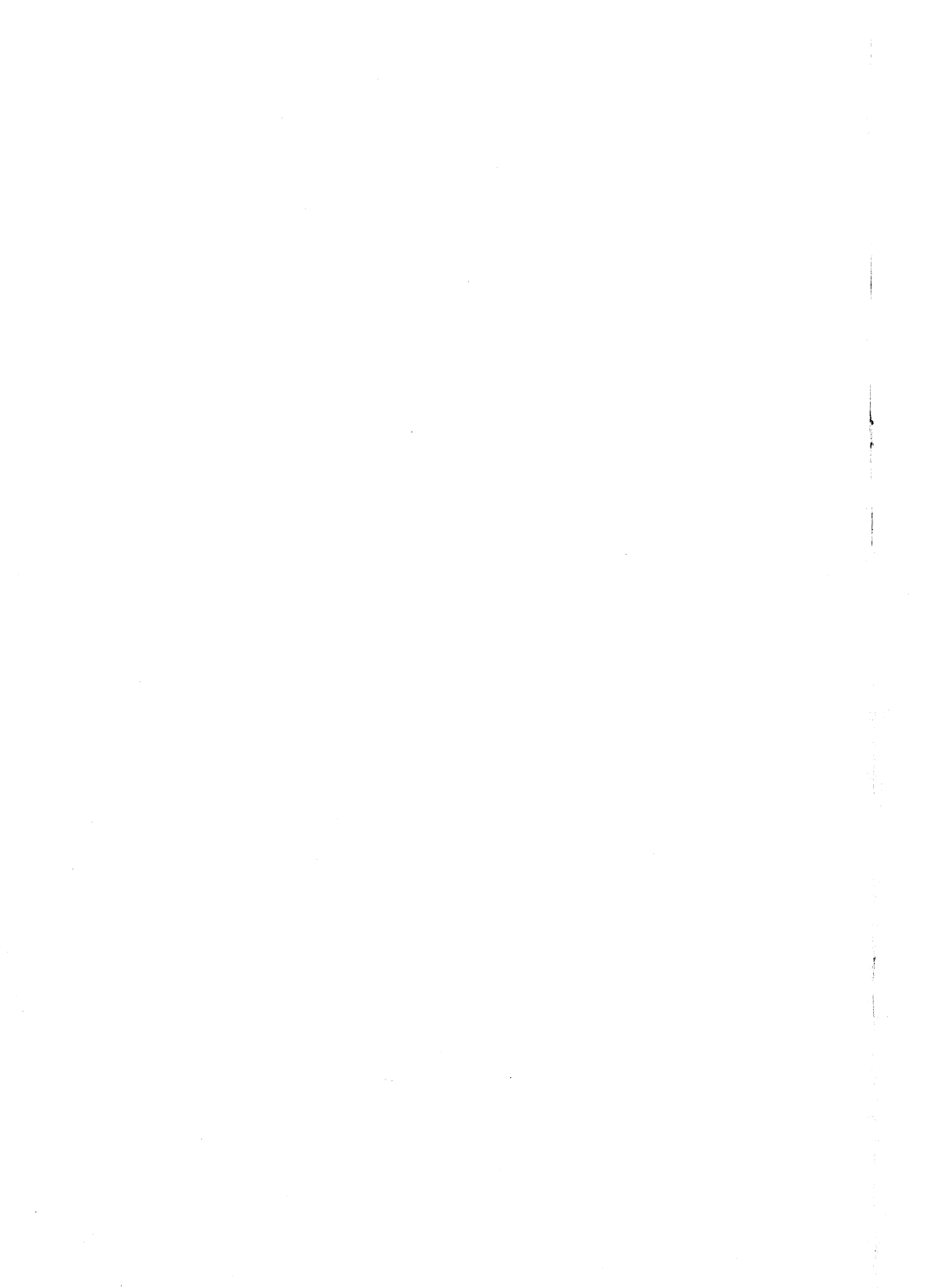
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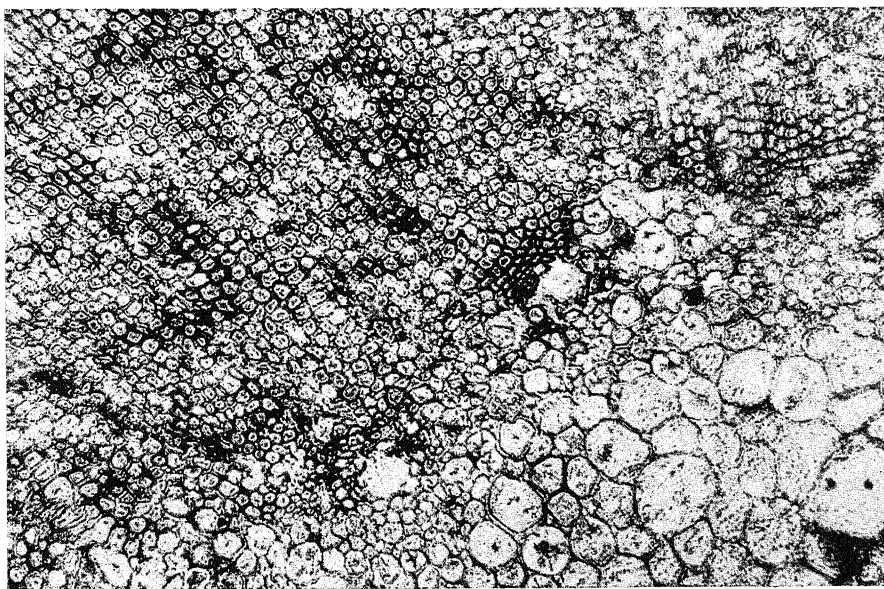
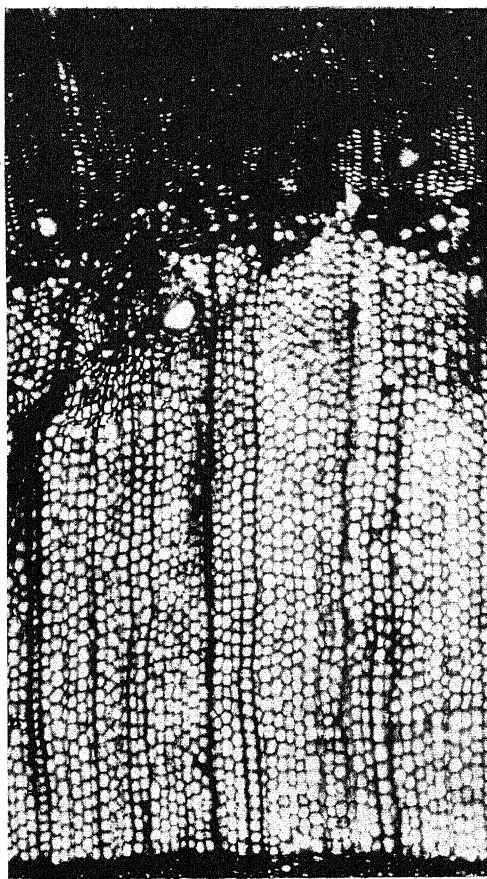
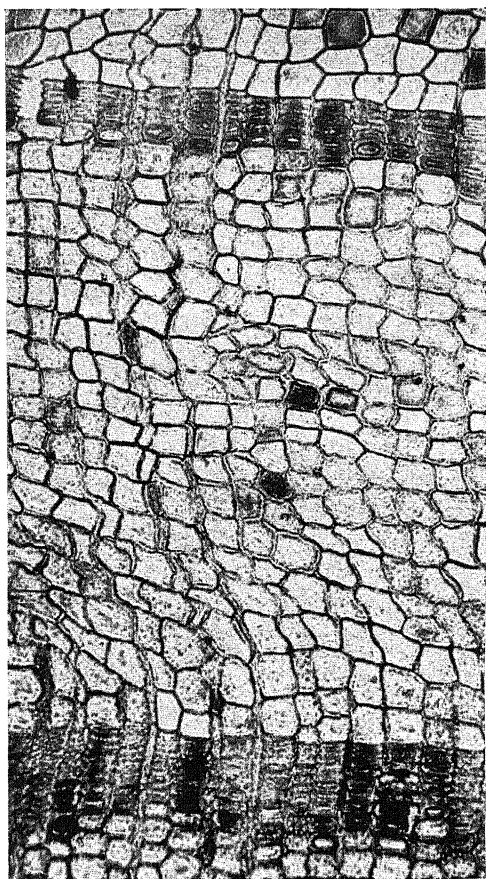


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*Cupressinoxylon lamarensis*

FIG. 1—Transverse section.  $\times 60$ . FIG. 2—Tangential section.  $\times 60$ .  
FIG. 3—Transverse section.  $\times 40$ .





3

FIG. 1—*Sequoia magnifica*, transverse section.  $\times 120$ .





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II

THE TROUT CREEK FLORA OF SOUTHEASTERN  
OREGON

By HARRY D. MACGINITIE

With sixteen plates

[Issued October 26, 1933]

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# THE TROUT CREEK FLORA OF SOUTHEASTERN OREGON

## INTRODUCTION

It is the purpose of this paper to describe a small flora from the Trout Creek Formation of Southern Harney County, Oregon, approximately 30 miles southeast of Alvord Branch and 2 miles northeast of the fork of Trout Creek.

The first published account of the flora is contained in Waring's paper, *The Geology and Water Resources of the Harney Basin, Oregon*.<sup>1</sup> In the summer of 1907 Waring sent a small collection to Knowlton who assigned an Eocene age to the plant beds. Furlong and Stock, while exploring for vertebrate fossils in 1923, made a small collection at the locality and sent it to R. W. Chaney at the University of California. A preliminary list<sup>2</sup> has been published and the material referred to the Miocene on the basis of its resemblance to the Mascall flora. The present paper is based on the material obtained by Stock and Furlong and on a series of specimens purchased from Mr. Percy Train during the period from 1928 to 1932. Both of these collections are in the paleobotanical museum of the University of California. The writer has also examined some thousands of additional specimens obtained by Mr. Train in the course of his collecting.

The name Trout Creek Formation was first used by W. D. Smith<sup>3</sup> in his description of the geology of the region. The general geology of the area has been well discussed by Fuller and Waters<sup>4</sup> and by Fuller.<sup>5</sup> Kirkham,<sup>6</sup> in a recent paper, has summarized and developed the present knowledge of the geology of the extreme southeastern portion of Oregon and the adjacent portions of Idaho, and has compiled lists of the fossil floras. The following general account of the geology and topography is taken from the paper by Fuller above cited, to which the reader is referred for a more complete discussion.

"In southern Oregon, east of the Cascade Range, a varied series of late Tertiary lavas is cut by the northern continuation of the Basin Range faults. The differential movement of the fault blocks has resulted in the

<sup>1</sup> U. S. Geol. Surv. Water Supply Paper No. 231, 19-20, 1909.

<sup>2</sup> Chaney, Carnegie Inst. Wash. Pub. No. 349, 31, 1925.

<sup>3</sup> *Contribution to the Geology of Southeastern Oregon*, Jour. Geol., vol. 35, 421-441, 1927.

<sup>4</sup> *The Nature and Origin of the Horst and Graben Structure of Southern Oregon*, Jour. Geol., vol. 37, 204-239, 1929.

<sup>5</sup> Univ. Wash. Pub. Geol., vol. 3, No. 1, 10, 1931. Also excellent aeroplane views of the region.

<sup>6</sup> *Revision of the Payette and Idaho Formations*, Jour. Geol., vol. 39, 193-239, 1931. Contains excellent bibliography.

formation of . . . depressions which are commonly bounded by precipitous fault scarps, varying in height from a few hundred to several thousand feet.

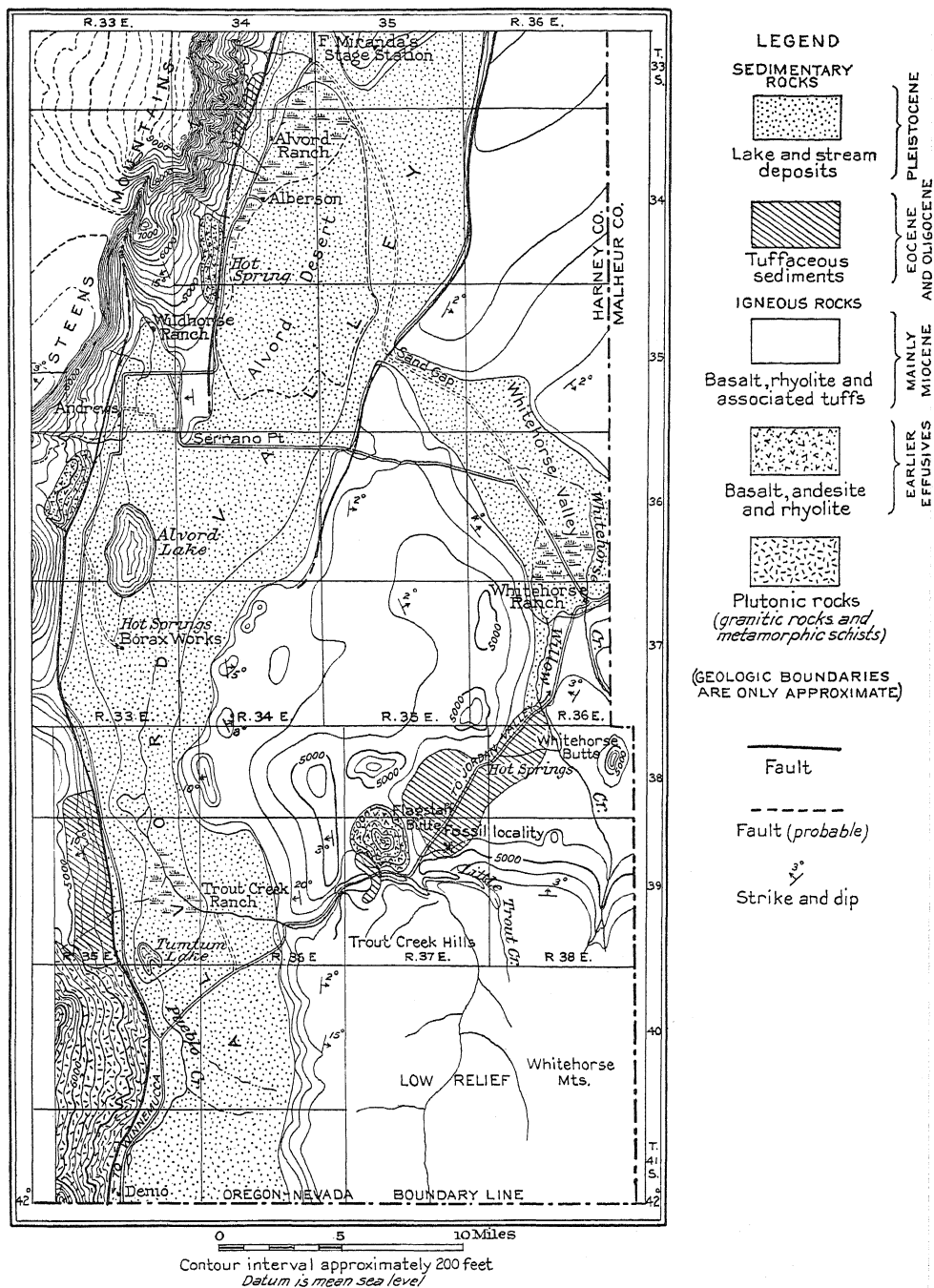
"These . . . depressions are all relatively flat-floored, owing to the accumulation of sediments in the vast system of lakes which they once formed. The many, partially eroded beach terraces on the scarps about the region testify to a previous depth of water of about 300 feet above the lake deposits, which in themselves are probably many hundred feet in depth. The surface of the bolson deposit, varying but slightly in the different basins, is over 4000 feet in elevation. Since the melting of the Pleistocene glaciers . . . the lakes have diminished until now their former presence is indicated chiefly by playa flats . . .

"The depressions, or grabens, are bounded longitudinally by the steep scarps of the gently tilted fault-blocks that border them. Many of these blocks are bounded by faults on both sides, and, in consequence, give rise to true horst and graben structure . . . As a rule, the blocks dip away from the major fault.

"Only the two highest scarps in the region have been appreciably modified by stream erosion. These . . . are the high eastern face of Steens Mountain and the western side of Hart Mountain . . . Owing to their elevation and the consequent greater rainfall, these mountains have many small, active streams. The principal erosion probably was, however, confined to the Pleistocene, when the climate is thought to have been more humid . . . these two localities form the centers of the principal volcanic activity of the region, for the magnificent exposures in the numerous valleys that cut the scarps furnish ideal opportunities for arriving at an interpretation of many of their volcanic phenomena. The higher members of the series, however, have survived erosion only on the lower scarps, which lack the stratigraphic complexity of these two localities. As a consequence, their complete interpretation involves merely the study of sections at a few carefully chosen localities."

#### ACKNOWLEDGMENTS

This paper was written under the auspices of the Carnegie Institution of Washington, which has supplied the necessary funds for the field work and for the preparation and publication of the manuscript. The writer desires in particular to express his gratitude to Dr. Ralph W. Chaney for his generous assistance and encouragement. Miss Mary Bowerman, graduate student in Botany, made some of the preliminary determinations, and Miss Susan Potbury, research assistant to Dr. Chaney, has helped in the determinations and in the preparation of the manuscript. Mr. Percy Train, commercial paleontologist, from whose property all of the fossil material came, has been very kind in loaning specimens for study. It is true that any scientific paper, no matter how large or small, is a composite work, and the writer wishes here to express his gratitude to all those who have generously assisted in the preparation of this paper.



Reconnaissance Geologic Map of the Trout Creek Region. Adapted from  
U. S. Geological Survey Water Supply Paper, No. 231.

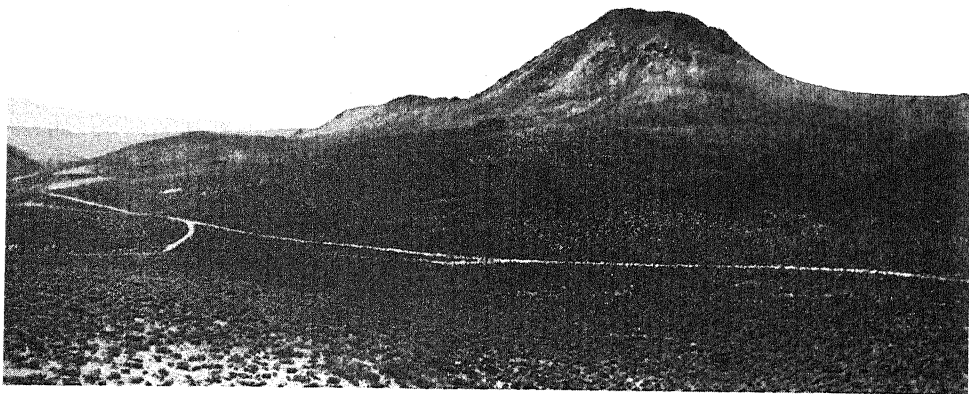


FIG. 1—Flagstaff Butte, a prominent landmark west of the leaf quarry. Flanks of the butte and the terrain in the foreground are composed of tuffs and agglomerate. The opalized diatomite appears as a white exposure to right of road on extreme left. Road leads into Trout Creek Valley; beyond this is scarp of greenish rhyolite.

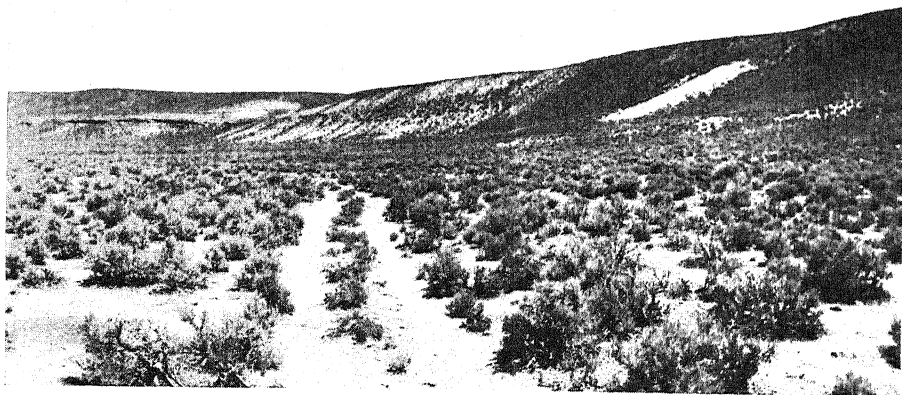


FIG. 2—The leaf quarries in the diatomite. A large part of the material for this paper came from quarries on right above line of the road. Massive sandstone bed caps the the lower diatomite in the left distance.

## GENERAL GEOLOGIC FEATURES OF THE TROUT CREEK REGION

On account of its isolated position and its altitude of over 6000 feet, Flagstaff Butte is the dominant topographic feature of the lower Trout Creek Valley, where it rises on the north side 1600 feet above the level of the stream. The mountain is composed of a varied series of effusives—flows, tuffs and agglomerates, whose areal distribution indicates that the structure is a volcanic neck or plug. A glassy, laminated rhyolite forms the major part of the Butte above 5400 feet elevation. On the slopes below this is a series of massive, reddish agglomerates, or coarse, fragmental tuffs and interbedded, fine-grained rhyolite tuffs, the whole series having a thickness of about 400 feet. These agglomerates were deposited on a massive, greenish rhyolite, the oldest rock exposed, which is separated from the upper effusives by an erosional unconformity.

East and northeast of the Butte is the wide, nearly level valley of Willow Creek, enclosed on the north and south sides by ridges of the agglomerate. Outcrops of the light-colored, diatomaceous lake sediments of the Trout Creek Formation are visible in many places below the agglomerate on the sides of the ridges and along the course of Willow Creek. These outcrops enclose an area of approximately 70 square miles, and the original basin of deposition must have been larger than this, for the sediments disappear under the volcanics on the north and east sides. A thin flow of olivine basalt occurs in several places on the immediate surface of the lake sediments. Trout Creek and Little Trout Creek follow the line of a fault which has a small upthrow on the south side of the stream; the diatomaceous sediments outcrop on the north side of Little Trout Creek but are cut off by the fault, and do not appear on the south side of the stream.

The stratigraphic relations of the volcanics which overlie the lake-beds could not be ascertained with certainty, but a similar reddish agglomerate exposed in Trout Creek Canyon south and east of Flagstaff Butte passes under a great thickness of basic lavas which form the elevation of the Trout Creek Hills and Whitehorse Mountains.

A tongue of the diatomaceous sediments extends to the southeast base of the Butte, where it has been altered to a pure white opalite by the action of the volcanics. The opalite is approximately 40 feet thick at this outcrop and rests on the older rhyolite. The same horizon, exposed on the side of a ravine which cuts the southeast flank of Flagstaff Butte, contains numerous fragments, branches and stumps of silicified wood, which indicate the location of the shore of the lake in which the sediments were deposited.

The Trout Creek Formation, where it outcrops along the north side of the ridge east of the Butte, has a total exposed thickness of about 200 feet, although the actual thickness may be considerably

greater. The strata dip eastward  $3^{\circ}$  or  $4^{\circ}$ . About midway in the measured section is a massive bed of fine, grey, tuffaceous sandstone, 15 feet thick. Above this, there are nearly 100 feet of sediments composed of pure white diatomite with a few thin layers of sand and tuff interbedded. The diatomite consists entirely of well-preserved diatom skeletons with scattered spicules of a fresh-water sponge. Below the massive sandstone bed, the interbedded sandy and tuffaceous layers are more numerous. They vary from 1 inch to 6 feet in thickness and are separated by beds of diatomite from 1 inch to 3 feet thick, except at the base of the measured section where a stratum of diatomite 12 feet thick is exposed. The diatomite layers in the lower half of the formation contain most of the plant remains; the interbedded sandstone layers are barren and the upper diatomite beds only sparsely fossiliferous. The leaves are distributed evenly through the matrix; they rarely overlap, and are obtained by quarrying large blocks and splitting the material parallel to the bedding planes.

Just west of Flagstaff Butte, exposed in a narrow graben, which extends in a north-south direction, are similar diatomaceous beds overlying and intergrading into a considerable thickness of brown sandstone and fine, sandy conglomerate, which have the appearance of flood-plain deposits. A section of these sediments is exposed in the face of a small westward-facing scarp on the east side of the graben about a mile south of the Butte. These beds contain a vertebrate fauna collected by Stock in 1923. The diatomaceous sediments in the graben west of Flagstaff Butte have no visible connection with those on the east side and may not be of the same age.

The graben is bounded on the west by a precipitous scarp of the older rhyolite, 500 to 700 feet high. Beyond the scarp, Trout Creek has cut a small canyon down to the floor of Alvord Valley. The rhyolite may be seen in the walls of the canyon dipping westward at an angle of  $20^{\circ}$  for a distance of 3 miles, until it passes under the sediments of the valley. This great apparent thickness may be due to repetition of the strata by faulting.

About 25 miles to the northwest, at the base of the Steens Mountain volcanic series, just west of Alvord Ranch, are extensive outcrops of bedded tuffs which Fuller has called the Alvord Creek Beds. These beds contain fossil leaves of probable Mascall age, and several of the species are found in the Trout Creek Formation.

#### PRESENT CLIMATE

The average elevation of the flat-floored valleys is about 4100 feet, with the bordering plateaus in some cases ascending to 5500 feet. The higher edges of the scarps have a still greater elevation. Steens Mountain, northwest of the fossil locality, has an elevation of ap-



proximately 10,000 feet. This high altitude gives a moderately low mean annual temperature of about 45° to 50°, with winter temperatures which may go below zero, and occasional summer temperatures of 100°.

The average rainfall varies from about 10 inches in the southern part of the district to 15 inches along the northern edge of Harney County. A large part of the precipitation comes in the winter half of the year, although on the higher elevations there is a secondary maximum in the spring. The three summer months, June, July and August, are practically rainless throughout the region with the exception of infrequent thunder showers in the mountains.

At moderate elevations there is an annual snowfall of from 20 to 40 inches and snow lies on the ground from 35 to 40 days per year. On the higher elevations the snowfall is much greater.

### PRESENT VEGETATION

The lower elevations, and some of the higher elevations up to 9000 feet, are occupied by the widespread vegetational unit which Clements<sup>1</sup> has designated as the Basin Sagebrush Formation and which Shantz<sup>2</sup> has called the Northern Desert Shrub. The prevailing association is the *Atriplex-Artemisia* association: abundant *Artemisia tridentata* Nutt. with *Atriplex confertifolia* Wats. *Sarcobatus vermiculatus* (Hook.) Torr. (greasewood) grows on the more saline soils. The Petran Chaparral Formation (Clements) forms sporadic coverings in the more mesophytic situations at middle altitudes. *Purshia tridentata* DC. and *Cercocarpus ledifolius* Nutt. constitute the major part of this community, and interspersed with these are shrubs of *Prunus melanocarpa* (A. Nels.) Rydb. and *Amelanchier alnifolia* Nutt. with *Salix* sp. and *Alnus tenuifolia* Nutt. around springs or along the water-courses. On the higher elevations *Juniperus occidentalis* Hook. or *Juniperus utahensis* (Engelm.) Lemmon are distributed among the chaparral and, toward the north, scattered trees of *Pinus ponderosa* Dougl. (*P. brachyptera* Engelm.) grow with the junipers. Enough grass to furnish grazing for flocks of sheep grows on the lowlands in the spring and on the higher mountains in summer.

During the summer season the vegetation in the valley of Trout Creek offers a refreshing contrast to that of the sagebrush-covered hills. Many herbs and tall grass cover the open spaces and the banks of the stream are overgrown by small trees of *Salix caudata* var. *bryanti* Ball, *Salix lutea platyphylla* Ball, *Alnus tenuifolia*, *Prunus melanocarpa* and *Cornus stolonifera* Michx., with an occasional small

<sup>1</sup> *Plant Indicators*, Carnegie Inst. Wash. Pub. No. 290, 156-160, 1920.

<sup>2</sup> *Atlas of Amer. Agric.*, Pt. I, sec. E, 21-22, 1924.

ee of *Elæagnus commutata* Bernh. Dense thickets of *Rosa* and scattered shrubs of *Ribes* grow in the meadows and *Clematis ligusticifolia* Nutt. grows among the shrubs at the edges of the thickets.

## COMPOSITION OF THE FLORA

There are 45 species in the Trout Creek flora as now known, which fall into 37 genera and 25 families. The dicotyledons make up 37 of the species, while of the remaining number 3 are monocotyledons and 1 are conifers. Among the dicotyledons 19 species are arborescent, 1 species shrubs, 3 or possibly 4 are woody climbers, and 3 are herbs.

## SYSTEMATIC LIST OF SPECIES

Permatophyta	Ranales
Gymnospermæ	Ranunculaceæ
Coniferales	Clematis reticulata
Pinaceæ	Berberidaceæ
Pinus knowltoni	Odostemon hollicki
Picea lahontense	Odostemon simplex
Pseudotsuga masoni	Nymphæaceæ
Abies laticarpus	Nymphæa diatoma
Cupressaceæ	Rosales
Thuites sp.	Rosaceæ
Angiospermæ	Spiræa (?) sp.
Monocotyledoneæ	Rosa hillia
Pandanales	Sorbus alvordensis
Typhaceæ	Cratægus gracilens
Typha lesquereuxi	Amelanchier grayi
Arales	Saxifragaceæ
Araceæ	Hydrangea bendirei
Lysichiton nevadensis	Leguminosæ
Liliales	Leguminosites sp.
Liliaceæ	Geraniales
Smilax magna	Rutaceæ
Dicotyledoneæ	Ptelea miocenica
Salicales	Sapindales
Salicaceæ	Sapindaceæ
Salix sp.	Sapindus affinus
Populus lindgreni	Celastraceæ
Juglandales	Euonymus (?) montana
Juglandaceæ	Aceraceæ
Juglans oregoniana	Acer chaneyi
Fagales	Acer merriami
Betulaceæ	Acer negundoides
Carpinus grandis	Acer osmonti
Betula lacustris	Acer scottiae
Alnus carpinoides	Rhamnales
Fagaceæ	Vitaceæ
Quercus consimilis	
Quercus klamathensis	
Quercus simulata	

Ericales	Asclepiadales
Ericaceæ	Asclepiadaceæ
Rhododendron (?) sp.	Vincetoxicum (?) trinervata
Arbutus trainii	Asterales
Gentianales	Compositæ (Tribe-Cynaréæ)
Apocynaceæ	Saussurea (?) sp.
Apocynum indiana	Incertæ sedis
Oleaceæ	Phyllites oregonianus
Fraxinus sp.	

The fossil material occurs as impressions of leaves, twigs, fruits, flowers and, in the case of the *Nymphæa*, as impressions or rootstocks. Impressions of fruits are fairly plentiful; several of the species are represented by both leaves and fruits. The genus *Lysichiton* is based on a fruiting spadix, and *Hydrangea* on impressions of flowers.

Although no exact quantitative data are available, the relative abundance of the various species is approximately known. The leaves of the evergreen oaks are by far the most abundant, making up more than half of all the leaves found, with *Betula*, *Arbutus*, *Acer*, *Salix*, *Amelanchier*, the conifers, *Odostemon*, and *Typha* following in the order given. The remaining leaf types are comparatively rare, amounting to but a small fraction of the total leaves found. *Thuites* and *Pinus* are the most abundant of the conifers, although the remaining coniferous species are not rare, and the members of this group are more common than is usual in other Miocene floras of western America. With due allowance made for leaf texture and proximity to the site of deposition, it is apparent that the forest of that time was a mixed assemblage of evergreen oaks and conifers, with maple and madrone abundant.

In order to facilitate comparisons between the Trout Creek flora and similar living floras, tables 1 and 2 have been prepared, showing the distribution of the nearest equivalent living species and the Trout Creek genera among four regions whose floras show marked similarity to the fossil flora.

The regions chosen are: (1) the Klamath Mountain area of northwestern California and southwestern Oregon; (2) the northeastern United States; (3) the southwestern states and northern Mexico; and (4) northeastern Asia, with particular reference to northern Japan and Manchuria. Specific comparisons between some of the fossil species and living species can not be satisfactorily made on foliar characters only; this is true of *Crataegus* sp., *Smilax* sp. and *Salix* sp. In other cases the specific resemblances between the living species and the fossil species are so close that no general differences between them can be established; this is illustrated by *Quercus* cf. *chrysolepis*, *Acer* cf. *glabrum*, *Abies* cf. *magnifica* and *Amelanchier* cf. *alnifolia*. The

similarities are not all as striking as these last examples, and thus there are varying degrees of similarity which can not be shown in the table, although each specific resemblance is the closest that could be determined. This fact must be considered in drawing conclusions from the data presented in the tables.

TABLE 1—*Distribution of the nearest living equivalents of the Trout Creek species.*

Species		Geographic regions			
Fossil	Living	Klamath Moun- tains	North- eastern States	South- western States	East- ern Asia
<i>Abies laticarpus</i> .....	<i>Abies magnifica</i> .....	X			
<i>Acer osmonti</i> .....	<i>Acer glabrum</i> .....	X			
<i>Acer merriami</i> .....	<i>Acer macrophyllum</i> .....	X			
<i>Acer negundoides</i> .....	<i>Acer negundo</i> .....		X	X	
<i>Acer scottiae</i> .....	<i>Acer pictum</i> .....				X
<i>Acer chaneyi</i> .....	<i>Acer saccharinum</i> .....		X		
<i>Alnus carpinoides</i> .....	<i>Alnus tenuifolia</i> .....	X		X	
<i>Amelanchier grayi</i> .....	<i>Amelanchier alnifolia</i> .....	X			
<i>Apocynum indiana</i> .....	<i>Apocynum cannabinum</i> .....	X	X		
<i>Arbutus traini</i> .....	<i>Arbutus menziesii</i> .....	X			
<i>Betula lacustris</i> .....	<i>Betula papyrifera</i> .....		X		
<i>Carpinus grandis</i> .....	<i>Carpinus laxiflora</i> .....				X
<i>Clematis sp.</i> .....	<i>Clematis fusca</i> .....				X
<i>Cratægus gracilens</i> .....	<i>Cratægus douglasii</i> .....	X			
<i>Euonymus (?) montana</i>	<i>Euonymus atropurpureus</i> .....		X		
<i>Fraxinus sp.</i> .....	<i>Fraxinus oregona</i> .....	X			
<i>Hydrangea bendirei</i> .....	<i>Hydrangea paniculata</i> .....				X
<i>Juglans oregoniana</i> .....	<i>Juglans nigra</i> .....		X		
<i>Lysichiton nevadensis</i> .....	<i>Lysichiton kamtschaticense</i> .....	X			X
<i>Nymphæa diatoma</i> .....	<i>Nymphæa odorata</i> .....		X		
<i>Odostemon hollicki</i> .....	<i>Odostemon aquifolium</i> .....	X			
<i>Odostemon simplex</i> .....	<i>Odostemon fremontii</i> .....			X	
<i>Picea lahontense</i> .....	<i>Picea engelmannii</i> .....	X		X	
<i>Pinus knowltoni</i> .....	<i>Pinus attenuata</i> .....	X			
<i>Populus lindgreni</i> .....	<i>Populus tremuloides</i> .....	X			
<i>Pseudotsuga masoni</i> .....	<i>Pseudotsuga taxifolia</i> .....	X		X	
<i>Ptelea miocenica</i> .....	<i>Ptelea trifoliata</i> .....		X	X	
<i>Quercus consimilis</i> .....	<i>Quercus myrsinaefolia</i> .....				X
<i>Quercus klamathensis</i> .....	<i>Lithocarpus densiflora</i> .....	X			
<i>Quercus simulata</i> .....	<i>Quercus hypoleuca</i> .....			X	
<i>Quercus traini</i> .....	<i>Quercus chrysolepis</i> .....	X			
<i>Sapindus affinis</i> .....	<i>Sapindus drummondii</i> .....			X	
<i>Sorbus alvordensis</i> .....	<i>Sorbus sitchensis</i> .....	X			
<i>Typha lesquereuxii</i> .....	<i>Typha latifolia</i> .....	X	X		X
<i>Vitis chaneyi</i> .....	<i>Vitis labrusca</i> .....		X		X
Total species.....		19	10	8	8
Percentage of total Trout Creek species (45).....		42	22	18	18

The Klamath Mountain element is the most significant group in the flora, since it contains all but two of the numerically dominant species and has the largest representation of similar species. It is the only element that has madrone in combination with the evergreen oaks, maples, Douglas fir and Port Orford cedar. Two of the genera,

*Ptelea* and *Juglans*, while not listed as members of the Klamath Mountain flora, are found in the California Coast Ranges south of the Klamath Mountains, and *Acer* cf. *negundo* also grows in the Coast Ranges south of San Francisco Bay. This Klamath Mountain ele-

TABLE 2—Modern distribution of the Trout Creek genera.

Genera	Geographic regions			
	Klamath Mountains	Northeastern States	Southwestern States	Eastern Asia
<i>Abies</i> .....	X	X	X	X
<i>Acer</i> .....	X	X	X	X
<i>Alnus</i> .....	X	X	X	X
<i>Amelanchier</i> .....	X	X	X	X
<i>Apocynum</i> .....	X	X		
<i>Arbutus</i> .....	X		X	
<i>Betula</i> .....	X	X	X	X
<i>Carpinus</i> .....		X		X
<i>Chamaecyparis</i> .....	X	X		X
<i>Clematis</i> .....	X	X	X	X
<i>Crataegus</i> .....	X	X	X	X
<i>Euonymus</i> .....	X	X		X
<i>Fraxinus</i> .....	X	X	X	X
<i>Hydrangea</i> .....		X		X
<i>Juglans</i> .....		X	X	X
<i>Lysichiton</i> .....	X			X
<i>Nymphaea</i> .....		X		X
<i>Odostemon</i> .....	X		X	X
<i>Picea</i> .....	X	X	X	X
<i>Pinus</i> .....	X	X	X	X
<i>Populus</i> .....	X	X	X	X
<i>Pseudotsuga</i> .....	X		X	X
<i>Ptelea</i> .....		X	X	
<i>Quercus</i> .....	X	X	X	X
<i>Rhododendron</i> (?).....	X	X		X
<i>Rosa</i> .....	X	X	X	X
<i>Salix</i> .....	X	X	X	X
<i>Sapindus</i> .....			X	X
<i>Saussurea</i> (?).....	X		X	X
<i>Smilax</i> .....	X	X	X	X
<i>Sorbus</i> .....	X	X		X
<i>Spiraea</i> (?).....	X	X		X
<i>Typha</i> .....	X	X	X	X
<i>Vincetoxicum</i> (?).....			X	
<i>Vitis</i> .....	X	X	X	X
Total genera.....	28	28	25	31
Percentage of total Trout Creek genera (37).....	76	76	66	84

ment will be more fully discussed in the chapter on the physical conditions indicated by the flora.

The element found in the northeastern states contains many of the characteristic mesophytic types of the fossil flora, yet it lacks certain essential forms which give the fossil assemblage its distinctive physiognomy, namely the madrone, Douglas fir and the group of

evergreen oaks. This element also contains *Hydrangea* and *Carpinus*, both of which are not found in the Klamath Mountain area but are common to eastern North America and eastern Asia. The Trout Creek flora is not typical of the Miocene floras of western North America, since it lacks many of the genera of broad-leaved deciduous trees, such as *Nyssa* and *Magnolia* which at present are living in eastern North America and eastern Asia, and which have been identified from the Latah, Mascall and Eagle Creek floras.

The flora of the southwestern states and northern Mexico has the least similarity to the fossil flora. It contains the *Arbutus* and evergreen oaks but lacks some of the important mesophytic forms such as *Thuites* cf. *Chamaecyparis*. It also contains a group of plants, *Sapindus*, *Vincetoxicum* (?), and *Odostemon* cf. *fremontii*, which appear somewhat out of place in the plant association of the fossil flora; it is possible that these modern types are more xerophytic than their fossil equivalents.

The Asiatic element has the largest number of genera represented, as it contains genera common to both eastern North America and to the Pacific Coast. The resemblance is even closer than the large representation of genera and the number of similar species would indicate, since some of the genera, such as *Amelanchier asiatica* Endl., *Acer henryi* Pax, *Pseudotsuga davidiana* Bertrand and *Populus tremula* L., are closely similar to the fossil species. *Arbutus* is the only important member of the Trout Creek flora which is absent from eastern Asia.

The smallest representation of genera for any region amounts to 36 per cent of the total, and the percentage of the total genera occurring in eastern Asia amounts to 84 per cent. This aspect of the flora is in keeping with the cosmopolitan character of Miocene floras in general.

## PHYSICAL CONDITIONS

### HABITAT CONDITIONS INDICATED BY THE FLORA

The flora may be divided into four groups according to the habitats of the living equivalents of the species. This grouping is shown below for some of the more typical forms.

- |                              |                          |
|------------------------------|--------------------------|
| 1. Lake and Marsh            | <i>Acer negundoides</i>  |
| <i>Lysichiton nevadensis</i> | <i>Alnus carpinoides</i> |
| <i>Nymphæa diatoma</i>       | <i>Betula lacustris</i>  |
| <i>Typha lesquereuxi</i>     | <i>Carpinus grandis</i>  |
|                              | <i>Fraxinus</i> sp.      |
|                              | <i>Rosa hilliae</i>      |
| 2. Stream-side or Riparian   | <i>Salix</i> sp.         |
| <i>Acer chaneyi</i>          | <i>Vitis chaneyi</i>     |

3. Mixed Slope and Upland	<i>Quercus traini</i>
<i>Acer merriami</i>	<i>Thuites</i> sp.
<i>Acer scottiae</i>	
<i>Arbutus traini</i>	4. Upland
<i>Pinus knowltoni</i>	<i>Abies laticarpus</i>
<i>Pseudotsuga masoni</i>	<i>Amelanchier grayi</i>
<i>Quercus consimilis</i>	<i>Picea lahontense</i>
<i>Quercus klamathensis</i>	<i>Sorbus alvordensis</i>

Since the flora contains these well-marked habitat groups, it is reasonable to conclude that it occupied a region of diversified relief. A tentative distribution according to life-zones, as shown in table 3, leads to the same conclusion. A majority of the plants might flourish in the Middle or Upper Transition Life-Zone, but there is a well-marked group which finds its most congenial habitat in the Canadian Life-Zone and another group of plants which are best developed in the Upper Sonoran or Carolinian Life-Zone. A distribution table of this kind can only be approximate, yet it brings out certain relations which can not be clearly shown otherwise.

Attention has been called to the general similarity between the Trout Creek flora and the present flora of the Klamath Mountains.<sup>1</sup> This region is one of varied relief, rising from sea-level to elevations of more than 9000 feet inland along the summits of the Salmon Mountains and Siskiyou Mountains, which form the backbone of the Klamath Mountain complex. The different habitat groups are encountered successively in going from the coast inland. The marsh plants, *Nymphaea polysepala*, *Typha latifolia* and *Lysichiton kamtschaticense*, grow in the coastal lagoons or in the meadow-ponds of the mountains inland above 4000 feet.

The Upper Sonoran or Lower Transition Life-Zone group, a typical riparian community, is widely distributed along the streams which flow westward from the mountains. *Rosa* spp., *Crataegus douglasii*, *Fraxinus oregona*, *Umbellularia californica*, *Smilax californica*, *Vitis californica*, *Clematis ligusticifolia* and *Populus tricocarpa*, with abundant *Alnus* spp., are intermingled with species from the Arid Transition Life-Zone along the stream-valleys at elevations up to 2500 feet.

The third group, the mixed slope and upland community, contains the major part of the numerical dominants of the Trout Creek flora. Their modern equivalents are found in the Klamath Mountains as *Lithocarpus* (tan oak), *Arbutus* (madrone), *Pseudotsuga* (Douglas fir), *Acer marcophyllum* (broad-leaved maple), *Quercus chrysolepis* (canyon live-oak) and *Chamæcyparis* (Port Orford cedar). The dominant assemblage is the tan oak-madrone-Douglas fir association

<sup>1</sup> Diller, U. S. Geol. Surv. Bull. 196, 1902.

with Port Orford cedar. This association is best developed on the level-topped ridges inland from the sea at elevations of from 1500 to 2000 feet. The tan oak-madrone-Douglas fir association is found from the central Oregon Coast Ranges south to southern California, and down the west slope of the Sierra Nevada to Placer County, and

TABLE 3—Distribution of the modern equivalents of the Trout Creek species according to life-zones

Species	Upper Sonoran Carolinian	Transition Alleghanian	Canadian	Hudsonian
<i>Abies magnifica</i>				
<i>Acer glabrum</i>				
<i>Acer macrophyllum</i>				
<i>Acer negundo</i>				
<i>Acer pictum</i>				
<i>Acer saccharinum</i>				
<i>Alnus tenuifolia</i>				
<i>Amelanchier alnifolia</i>				
<i>Apocynum cannabinum</i>				
<i>Arbutus menziesii</i>				
<i>Betula papyrifera</i>				
<i>Carpinus laxiflora</i>				
<i>Chamaecyparis lawsoniana</i>				
<i>Clematis fusca</i>				
<i>Crataegus douglasii</i>				
<i>Euonymus atropurpureus</i>				
<i>Fraxinus oregona</i>				
<i>Hydrangea paniculata</i>				
<i>Juglans nigra</i>				
<i>Lithocarpus densiflora</i>				
<i>Lysichiton kamschatcense</i>				
<i>Nymphaea odorata</i>				
<i>Odostemon aquifolium</i>				
<i>Odostemon fremontii</i>				
<i>Picea engelmannii</i>				
<i>Pinus attenuata</i>				
<i>Populus tremuloides</i>				
<i>Pseudotsuga taxifolia</i>				
<i>Ptelea trifoliata</i>				
<i>Quercus chrysolepis</i>				
<i>Quercus hypoleuca</i>				
<i>Quercus myrsinaefolia</i>				
<i>Sapindus drummondii</i>				
<i>Smilax</i> sp.				
<i>Sorbus sitchensis</i>				
<i>Vincetoxicum</i> sp.				
<i>Vitis labrusca</i>				

thus grows under a considerable range of temperature and rainfall. It is only in the northern part of its range, however, around the northern edge of the Redwood Belt in the humid Klamath Mountains, that it is associated with the *Chamaecyparis lawsoniana* (Port Orford cedar). It is this forest which seems to be most similar to the forest of Trout Creek time, and not the tan oak-madrone-Douglas fir



association in general. Although the tan oak was present in the Trout Creek forest, the leaves of *Quercus consimilis* are much more abundant, and this tree apparently held the ecological position in the Miocene forest that the tan oaks hold in the living forest.

Many of the Canadian Life-Zone species, listed as modern equivalents of the fossil species, grow on the higher elevations of the Klamath Mountains. Along the flat summit of South Fork Mountain or on the western slopes of the Salmon Mountains, the dominant association consists of *Abies magnifica* var. *shastensis* and *Abies concolor*, with *Pinus monticola* and *Tsuga mertensiana* less common. The rare *Picea breweriana* occurs in scattered groves at the heads of the canyons. *Amelanchier alnifolia*, *Acer glabrum*, *Sorbus sitchensis*, *Betula fontinalis* and *Populus tremuloides* grow along the mountain streams or in open situations in the forest. This group may be seen above Dedrick, near the headwaters of Canyon Creek, northwest of Weaverville. *Picea engelmannii* is rare in the Klamath Mountains, but is abundant at elevations of from 5000 to 6000 feet on the moist slopes of the Cascade Mountains west of the fossil locality.

The forest communities briefly discussed above are found from near sea-level to elevations above 6000 feet, with a minimum vertical range of not less than 4000 feet. This suggests a similar range in altitude for the forest of Trout Creek time. If the temperature ranges at that time were the same as those of today in the same latitude, an average elevation of not less than 2500 feet is indicated for the flora; if the temperatures of that time were higher it would mean a corresponding increase in the elevation of the life-zones.

The absence of deciduous oaks and *Sequoia* in the Trout Creek flora, both of which are found in the Mascall and Latah floras, may be satisfactorily explained by a consideration of the modern tan oak-madrone-Douglas fir-Port Orford cedar association, which normally contains neither *Sequoia* nor broad-leaved oaks. On the coastal side in California the tan oak forest grades into the typical redwood forest; inland it becomes more open and gives way to the Arid Transition Life-Zone forest where the two deciduous oaks, *Quercus garryana* (Oregon oak) and *Quercus kelloggii* (black oak), take the place of the tan oak. The change from the Humid Transition with tan oak and the Arid Transition with black oak is often abrupt and is accentuated in the fall of the year when the black oak assumes its autumnal coloring. The change from one association to the other may be completed within a distance of two or three miles. The deciduous oaks are rarely found in the tan oak forest of the Klamath Mountains, and where they do occur the habitat is on the dry, elevated ridges distant from the streams. No leaves of the broad-leaved deciduous oaks have yet been found in the Trout Creek flora,

and it is not likely that any will be discovered, since the habitat of the trees, if they were present in the region, would have been out of reach of the sedimentary record. The absence of *Sequoia* from the fossil flora is in keeping with the cool, upland character of the association. The presence of *Arbutus* and the group of evergreen oaks suggests that the flora was adjusted to endure a dry season, such as occurs today in the Klamath Mountains. The *Sequoia* is sensitive to frost, and to low humidity at any season of the year, and thus its presence is not to be expected in a plant community like that of the Trout Creek Formation.

Some aspects of the Trout Creek flora are quite different from those of the Klamath Mountain flora. Two of the abundant species, *Quercus consimilis* and *Acer scottiae*, have their modern equivalents now living in eastern Asia, and a few of the genera, such as *Carpinus*, are no longer members of the west-coast flora. The presence of five distinct species of maples in the forest community is not duplicated in any of the western American forests, but this number would not be unusual in the mountain flora of the northeastern states. This comingling of maples, coniferous types and evergreen oaks is suggestive of the floras of northeastern Asia and Japan, and the aspect of the flora as a whole is particularly like that of the flora of the north island of Japan, Hokkaido.

Asa Gray, in his paper on the *Flora of Japan*,<sup>1</sup> anticipated, by a kind of prophetic insight, many of the later discoveries of the paleobotanists. Researches during the last twenty years have only served to confirm his conclusions. The resemblance between the Miocene floras of western North America and the living flora of eastern Asia seems to be closer than that between the present flora of eastern North America and the eastern Asiatic flora. A group of broad-leaved deciduous trees has been eliminated from the west-coast flora since Miocene time. The Trout Creek flora, as now known, lacks, however, most of the characteristic deciduous trees of this Miocene flora, such as the elms, beeches, magnolias, hickories and others. The Latah flora of eastern Washington, which may be of nearly the same age as the Trout Creek flora, contains a group of arborescent genera<sup>2</sup> which are now absent from the west coast, but are at present living in both eastern North America and eastern Asia:

Carpinus	Liquidambar
Castanea	Liriodendron
Diospyros	Magnolia
Fagus (Fagopsis)	Nyssa
Ficus	Sassafras
Ginkgo	Tilia
Glyptostrobus	Ulmus
Hicoria	

Of this group, only one, *Carpinus*, has so far been identified in the Trout Creek deposit. The absence of the other genera may be explained by the fact that the Latah flora grew in a mesophytic, lowland region of deep, well-watered soils, while the Trout Creek forest grew in the uplands. The Mascall floras from the region to the south of the Latah flora show a similar group of exotic genera, but indicate a somewhat more varied relief than that of the Latah. The Trout Creek flora with its abundance of oaks and conifers is the type of plant community to be expected in an upland situation of Mascall time.

#### CONDITIONS INDICATED BY THE SEDIMENTS AND ASSOCIATED VOLCANICS

The comparatively thick beds of diatomite in the Trout Creek Basin indicate, although they do not necessarily confirm, a temperate climate during the time of deposition.<sup>1</sup> The manner in which the leaf fossils are preserved shows that the deposition of the enclosing matrix must have been fairly rapid. The leaves are seldom overlapped or in definite layers, but are fairly evenly distributed throughout the diatomite in the exposed part of the formation. No quantitative studies of the rate of deposition of diatomite have come to the writer's attention; however, if the temperature and food conditions are favorable, the limiting factor in the growth of diatoms is probably the amount of silica in solution. In ordinary fresh water the silica content is extremely small, but in regions of active volcanism this may be greatly increased both through the partial solution of the showers of volcanic dust which fall on the surface of the water and the presence of springs carrying hydroxyl ion and the ions of the alkali metals.<sup>2</sup> The formation is interbedded with acid effusive rocks and contains layers of nearly pure, fine-grained volcanic dust, indicating that the water may have contained a relatively large amount of silica in solution. The probable high silica content of the water, in combination with appropriate temperature and adequate supplies of food would promote the multiplication of diatoms at an enormous rate. The deposition of 2 or 3 inches of diatomite per year does not seem improbable under these conditions. Klamath Lake, on the southern border of Oregon southeast of Crater Lake, is now accumulating diatomite sediments similar to those in the fossil Trout Creek lake.<sup>3</sup> The lake-bottom has a deposit of diatom ooze of unknown depth which grades upward into a thin diatomite "soup." Leaves which are brought to the lake by winds or by inflowing streams

<sup>1</sup> Encyclopedia Britannica, 14th Edition, page 879.

<sup>2</sup> Clarke, U. S. Geol. Surv. Bull. No. 770, 111, 1924.

<sup>3</sup> G. Dallas Hanna, Oral communication, Aug. 1932.

become water-logged and slowly sink into the diatomite ooze. This would give the texture of the fossilized leaves a different appearance from leaves which have been preserved in volcanic dust or river clays. The *Arbutus* leaves of the Trout Creek deposits were evidently coriaceous, but their impressions in the diatomite give the appearance of thin texture due to the fact that the leaves were partially decomposed before preservation. Many of the impressions have lost all of the original organic and carbonaceous matter and appear as white prints in the diatomite.

The different species are segregated in the formation to a certain extent. Thus *Betula* is more abundant at the base of the exposed section; *Thuites* and *Berberis* are more plentiful in the upper layers; while the maples seem to be more abundant in the middle of the section. *Quercus consimilis* is plentiful at all levels. This segregation may have come about through variations in level of the lake and from storms and varying wind directions. It is hardly possible that topographic changes of sufficient magnitude to affect the character of the flora could occur during the life of the lake.

The skeletons of fresh-water fish are not uncommon in the deposit. This indicates that the lake had a balanced inflow and outflow of water. There are no evidences of pronounced seasonal variations of water-level. Vetebrate remains have been found in the flood-plain deposits which underlie the diatomite beds 3 miles southwest of the leaf quarry. Among these, *Merychippus* and mastodon have been tentatively identified.<sup>1</sup> These animals were browsing, forest types and would not be found in a region where the forests were confined to the stream-bottoms.

Fuller has given evidence, founded on a petrographic study of the Steens Mountain area, which suggests that a region of considerable elevation existed along the Oregon-Nevada boundary in the upper Miocene or lower Pliocene time.<sup>2</sup> The thick series of Steens Mountain basalts, considered to be of lower Pliocene age, ends abruptly against the older Canyon Rhyolite of northern Nevada, and south of the rhyolite the volcanic sequence is quite different. The basalt flows were evidently limited on the south by an elevated region which stood above the volcanic deposits and which was subject to erosion rather than to deposition.

The evidence of the flora and the associated sediments and fossils favors the conclusion that the region was generally forested and not one of mixed forests and grassy plains—a highland of considerable elevation and varied, although probably not strong, relief. The picture suggested by a study of the flora is that of a widespread

<sup>1</sup> Chester Stock, Written communication, Oct. 1932.

<sup>2</sup> Fuller, Univ. Wash. Pub. Geol., vol. 3, No. 1, 115, 1931.

basin, partly filled by an extensive, rather shallow, fresh-water lake and enclosed on the south and southwest sides by a volcanic mountainous region. The type of relief may not have been greatly different from that of the present Klamath Lake country. Frequent showers of volcanic dust fell on the surface of the lake and became intercalated with the sediments furnished by an abundant microflora of diatoms. *Typha*, *Lysichiton* and other hydrophytes grew along the marshy borders of the lake and *Nymphaea* in the open water. *Alnus*, *Betula*, *Acer*, *Fraxinus* and other riparian types were common around the shore and along the banks of the inflowing streams. The slopes above the lake, at moderate elevations, were occupied by a mixed forest of *Acer*, *Quercus*, *Arbutus* and various conifers, and the higher elevations supported forests of *Abies* and *Picea*.

#### CLIMATIC ASPECTS OF THE FLORA

The flora indicates a cool, temperate climate, quite different from that now prevailing in the region, but not unlike the present climate of the coastal mountains west of the fossil locality. Actual figures for the amount of rainfall based on evidence furnished by the plant formation may be subject to considerable error since the response of a plant community to rainfall depends on many variable factors, such as seasonal extremes of temperature, average annual temperature, soil conditions and seasonal distribution of rainfall. The living tan oak forest with Port Orford cedar is not found where the annual rainfall is less than 40 inches, and in the major part of the range of this forest type the rainfall exceeds that figure. In the Klamath Mountains the maximum rainfall occurs in the winter and there is a marked deficiency of precipitation in the months of June, July and August. The presence of abundant *Arbutus* and evergreen *Quercus* in the fossil flora suggests that it was adapted to tolerate a dry summer season. If a rainfall regime similar to that of the present in the Klamath Mountains prevailed during the life of the Trout Creek flora, an average annual rainfall of 40 inches would be a conservative estimate.

The presence of many genera in the Latah and Mascall floras which are now absent from the west coast, but which at the present time are growing in regions of adequate summer rainfall, indicates that the seasonal distribution of precipitation has changed since that time in this area. The climate of the Latah flora seems to have been similar to that of west central Europe today, with ample summer precipitation. The position of the Trout Creek flora, some 400 miles south of the Latah localities and 200 miles southeast of the Mascall localities, together with the elevation of its habitat, would account for a difference in seasonal precipitation.

The living plant community to which the Trout Creek association has been compared is only an approximation to the fossil association, although probably a close one, and thus the climatic conditions under which the present forest grows, can not be taken as an exact parallel to those prevailing at the time the fossil material was in process of deposition.

### AGE OF THE FLORA

In establishing the age of the flora, two sources of evidence may be considered: first, the numerical representation of its species in floras of known geologic age; second, its ecologic and climatic aspects as compared with other known floras. Table 4 shows that 19 of the species, or 42 per cent of the total, occur in the Mascall flora of north central and northeastern Oregon, while 9 of the species or 20 per cent are found in the related Payette flora. The Bridge Creek and Crooked River floras are represented by 7 and 8 species, respectively. The Trout Creek flora is thus most closely related numerically to the Mascall flora of Oregon. The correlation table, however, is inadequate as a means of completely determining the age of a flora, since it stresses the presence or absence only of a species, without regard to the place it takes in the plant assemblage. Some of the species which appear in the table may be rare stragglers in the flora and without much significance when the plant community as a whole is considered. It is necessary, therefore, to consider the dominant association of the flora and its relation to the similar assemblages of other related floras. Chaney, in his papers on the Bridge Creek, Crooked River and Mascall floras,<sup>1</sup> following the method suggested by Clements,<sup>2</sup> has developed the use of the plant community and its climatic and ecologic aspects and has proved its importance in establishing the age of the floras.

A comparison of the Trout Creek flora, from this standpoint, with the Bridge Creek and Mascall floras brings out some significant relations. The dominants of the Trout Creek forest, named approximately in the order of their numerical occurrence, are: (1) the narrow-leaved oaks, *Quercus consimilis* and *Quercus traini*; (2) *Arbutus matthesii*; (3) the maples, *Acer merriami* and *Acer scottiae*; (4) *Betula lacustris*; (5) the coniferous types, *Thuites*, *Pinus knowltoni*, and *Pseudotsuga masoni*. This association is like that of Bridge Creek in the abundance of narrow-leaved evergreen oaks and of betulaceous types, and like the Mascall in possessing a dominant group of maples; it differs from both in the absence of *Sequoia* and *Platanus* and in the

<sup>1</sup> Carnegie Inst. Wash. Pub. No. 346, 45-138, 1927; No. 349, 1-48, 1925.

<sup>2</sup> Carnegie Inst. Wash. Pub. No. 290, 99-103, 1920; Reports on the Conferences on Cycles,

TABLE 4—Distribution of the Trout Creek species among other Tertiary floras of the western states.

Species	Upper Oligocene to Lower Miocene			Middle Miocene to Upper Miocene								Upper Miocene to Lower Pliocene	Pliocene
	Bridge Creek	Crooked River	Eagle Creek	Payette	Mascall*	Alvord Creek	Latah	Grand Coulee	Ellensburg	Emeralda	Florissant	Dalles Beds	Pliocene of California
<i>Abies laticarpus</i> .....	..	..	..	..	?	..	..	..	..	..	..	..	..
<i>Acer chaneyi</i> .....	..	..	..	..	..	..	X	..	..	..	..	..	..
<i>Acer gigas</i> .....	..	..	..	X	X	..	..	..	..	..	..	..	..
<i>Acer merriami</i> .....	..	..	..	X	X	X	X	X	..	..	..	..	..
<i>Acer negundooides</i> .....	..	..	..	..	X	..	..	..	..	..	..	X	..
<i>Acer osmonti</i> .....	X	X	..	X	..	..	..	..	..	..	..	..	..
<i>Acer scottiae</i> .....	..	..	..	..	X	..	..	..	..	..	..	..	..
<i>Alnus carpinoides</i> .....	X	X	X	..	?	..	..	..	..	..	..	..	..
<i>Amelanchier grayi</i> .....	..	X	..	..	..	X	X	..	..	X	..	..	..
<i>Arbutus traini</i> .....	..	X	..	..	X	..	..	..	..	..	..	..	..
<i>Carpinus grandis</i> .....	X	X	..	..	X	..	..	..	..	X	..	..	..
<i>Fraxinus</i> sp.....	..	..	..	..	X	..	..	..	..	..	..	..	..
<i>Hydrangea bendirei</i> .....	..	..	..	..	X	..	..	..	..	..	..	..	..
<i>Juglans oregoniana</i> .....	..	..	..	X	X	..	..	..	..	..	..	..	..
<i>Lysichiton nevadensis</i> .....	..	..	..	..	..	..	..	?	..	..	..	..	..
<i>Nymphaea diatoma</i> .....	..	..	..	..	..	..	..	..	X	..	..	..	..
<i>Odostemon hollicki</i> .....	..	..	..	..	..	..	..	..	..	..	X	..	X
<i>Odostemon simplex</i> .....	X	X	..	..	X	..	..	..	..	..	..	..	..
<i>Phyllites oregonianus</i> .....	..	..	..	..	X	..	..	..	..	..	..	..	..
<i>Picea lahontense</i> .....	..	..	..	..	X	..	..	..	..	..	..	..	..
<i>Pinus knowltoni</i> .....	..	..	X	X	X	..	..	..	..	..	..	..	..
<i>Populus lindgreni</i> .....	..	..	..	X	X	X	..	..	X	..	..	..	..
<i>Pseudotsuga masoni</i> .....	..	..	..	..	..	X	..	..	..	..	..	..	?
<i>Ptelea miocenica</i> .....	..	..	..	..	..	..	..	X	..	..	..	..	..
<i>Quercus consimilis</i> .....	X	..	..	X	X	..	..	..	..	..	..	..	..
<i>Quercus simplex</i> .....	X	..	X	..	..	..	..	..	..	..	..	..	..
<i>Quercus simulata</i> .....	..	..	X	X	X	..	X	..	..	..	..	..	..
<i>Quercus traini</i> .....	..	..	..	X	..	..	..	..	..	..	..	..	?
<i>Rosa hilliae</i> .....	X	X	..	..	..	..	..	..	..	..	X	..	..
<i>Sapindus</i> sp.....	..	..	..	..	X	..	..	..	..	..	..	..	..
<i>Smilax magna</i> .....	..	..	X	..	..	..	..	..	..	..	..	..	..
<i>Sorbus alvordensis</i> .....	..	..	..	..	..	X	..	..	..	..	..	..	..
<i>Thuites</i> sp.....	..	..	..	..	X	..	..	..	..	..	..	..	..
<i>Typha lesquereuxi</i> .....	..	..	..	..	X	..	..	..	X	X	..	..	..
<i>Vitis chaneyi</i> .....	..	X	..	..	?	..	..	..	..	..	..	..	..
Total species.....	7	8	5	9	19	5	4	2	1	2	5	1	1
Percentage of total Trout Creek species (45).....	16	18	11	20	49	11	9	4	2	4	11	2	2

\* The Mascall group includes the Van Horn's Ranch, White Hills, Austin and Tipton localities. ? indicates presence of species probable, but not proven.

scarcity of *Juglans*. The complete absence of broad-leaved deciduous oaks from Trout Creek relates it to the Bridge Creek flora, since the oaks from this flora are small, non-lobed forms, with entire or serrate

margins. Those from Van Horn's Ranch (Mascall) are all, or nearly all, lobed forms.<sup>1</sup> Chaney,<sup>2</sup> in his paper on the Crooked River flora, says, "This element (the broad-leafed oaks) has never been found in the Bridge Creek flora of western North America or in corresponding floras of other continents, and it may be assumed not to have been a part of the typical Oligocene redwood forest." The evergreen oaks are fairly common, however, in other floras of Mascall age, particularly those from the Austin and Tipton localities in the Blue Mountains of Oregon. At least one of these evergreen oaks, *Quercus consimilis*, is a wide-ranging type geologically, occurring in the lower and upper Miocene; the same may be true of some of the other forms, so that their presence in a flora, while not of particular stratigraphic significance, is useful as an indication of certain habitat conditions.

The absence of *Sequoia* and *Platanus* as well as the scarcity of *Juglans* is explained by the upland character of the Trout Creek forest. In the discussion of the ecology and habitat of the flora it has been shown that considerable relief must have existed in the region, and it may be noted that the group of dominants is not found in lowland habitats today. A forest having a similar dominant association is found at present as a marginal forest within the northern Redwood Belt or around its northern border. In these situations, unsuited to the redwood, *Lithocarpus densiflora*, *Arbutus menziesii*, *Pseudotsuga taxifolia*, *Chamaecyparis lawsoniana*, *Pinus attenuata*, *Quercus chrysolepis*, *Acer macrophyllum* and *Acer circinatum* make up a large part of the forest community. In contrast to this, the plant association of the Mascall has more of the character of the border vegetation around the southern portion of the Redwood Belt where two species of broad-leafed oaks, *Quercus garryana* and *Quercus kelloggii*, are plentiful, and where *Platanus occidentalis* and *Juglans californica* grow along the stream-courses. The Trout Creek association indicates a more humid climate than the Mascall association and a cooler situation than either the Bridge Creek or Mascall associations, and seems to be, in some respects, intermediate between the two.

The age of the Bridge Creek flora was considered by Knowlton to be upper Eocene,<sup>3</sup> and the Mascall was assigned to the upper Miocene.<sup>4</sup> Chaney, whose intensive work on the Bridge Creek, Crooked River, Eagle Creek and Mascall floras gives authority to his statements, assigned the Bridge Creek to the upper Oligocene<sup>5</sup> and the Mascall of Oregon to the middle Miocene.<sup>6</sup> Recent work in lower

<sup>1</sup> Knowlton, U. S. Geol. Surv. Bull. 204, 96-97, 1902.

<sup>2</sup> Carnegie Inst. Wash. Pub. No. 346, 136, 1927.

<sup>3</sup> U. S. Geol. Surv. Bull. 204, 105, 1902.

<sup>4</sup> *Op. cit.*, 108.

<sup>5</sup> Carnegie Inst. Wash. Pub. No. 349, 22, 1925.

<sup>6</sup> *Op. cit.*, 47.



and middle Tertiary floras of Oregon indicates that the Bridge Creek flora may be assigned to a still later age, uppermost Oligocene or lower Miocene.<sup>1</sup> It follows that the most probable age for the Mascall floras is upper Miocene. If the absence of deciduous oaks were significant, it would tend to place the Trout Creek flora somewhat older than the Mascall, although the abundance of *Arbutus* and *Acer*, together with the large numerical representation of other species, closely relates it to the Mascall. The absence of *Sequoia* has sometimes been taken as an indication of the Pliocene age of a flora, but in the case of the Trout Creek forest the exclusion of *Sequoia* seems clearly to be due to topographic factors and not to any general climatic change.

Additional evidence in regard to the age of the flora is furnished by vertebrate fossils collected by Stock and Furlong in 1923 from the sedimentary beds below the diatomite south of Flagstaff Butte. These were assigned to the middle or upper Miocene.<sup>2</sup>

A consideration of the evidence presented above seems to justify the conclusion that the Trout Creek flora is nearly contemporaneous with the Mascall flora and is thus of upper Miocene age. The facial differences appear to be due largely to the higher elevation which the Trout Creek flora occupied and to the resultant greater rainfall.

### ASSOCIATED DIATOMS

Samples of the diatomite from the various outcrops were submitted to Dr. G. Dallas Hanna, Curator of Paleontology at the California Academy of Sciences, San Francisco, who has kindly written the following report on his findings.

#### FRESH-WATER DIATOMS FROM OREGON

By G. DALLAS HANNA

Mr. Harry MacGinitie recently submitted three samples of diatomite to me for examination. They came from important leaf-bearing beds of Harney County, Oregon, and it seems desirable that such information as is available regarding the diatoms present may well accompany the reports upon the other fossil plants.

An unmarked sample came from lake-beds one mile south of Flagstaff Butte, Harney County, Oregon; vertebrate remains have been collected deeper in the section. The sample is a very pure fresh-water diatomite, light in weight and loosely compacted. The dominant genus of diatom is *Fragilaria*.

*Cymbella* is very common. Other forms are rare. A deposit of similar diatoms to this is found in Sonoma County, California, and has been generally referred to the Pliocene.

<sup>1</sup> Chaney, Guidebook 21, Excursion C-2, XVI International Geol. Congress, Govt. Printing Office, 1932; Chaney and Sanborn, Carnegie Inst. Wash. Pub. No. 439, 61, 1933.

<sup>2</sup> Stock, Written communication, Oct. 4, 1932.

*Fragilaria construens* (Ehrenberg). Abundant.  
*Cymbella cistula* (Ehrenberg). Abundant.

*Melosira distans* (Ehrenberg). Common.  
*Cocconeis placentula* (Ehrenberg). Rare.

The *Melosira* has a set of large round beads, usually arranged in rows at angles of 60 degrees to each other. A lower focus on the flat surface shows only a central ring.

Two samples were numbered 275. Both came from leaf-beds of Trout Creek formation, 2 miles east of Flagstaff Butte, 30 miles southeast of Alvord Ranch, Harney County, Oregon. Both are excellent samples of very white, punky, fresh-water diatomite.

The sample marked "upper" consists almost entirely of a short-celled form of *Melosira granulata* (Ehrenberg). A few scattered fragments of *Fragilaria* and a small fragment of *Stephanodiscus* were seen.

The "lower" sample has more species than either of the others. The list identified is as follows:

*Synedra*, n. sp. Abundant  
*Tetracyclus lacustris* Ralfs. Abundant  
*Gomphonema occidentale* Schmidt. Rare  
*Navicula placentula* (Ehrenberg). Rare

*Melosira granulata* (Ehrenberg). Abundant  
*Melosira arenaria* (Moore). Common  
*Stephanodiscus*, n. sp. Common  
*Cymbella* sp. Common

*Melosira granulata* occurs in many forms, that called *spiralis* by Grunow, being very common.

Almost all of the forms of *Tetracyclus* illustrated by Hustedt in Schmidt's Atlas are present. Also some others not shown there are very common, such as the one with very concave sides, similar to *Rhabdonema japonicum*. Since all occur together and show perfect intergradation in this one deposit, nothing would be gained by applying separate names to each individual variation.

The *Stephanodiscus* has a marginal row of heavy beads and the disk is covered with closely spaced small beads not arranged in radial rows or any other system. It is referred to *Stephanodiscus* solely upon the basis of the presence of the marginal beads. The marine genus *Thallasiosira* might be an equally fitting reference, but the only known fresh-water species, *fluvialilis* Hustedt, has very pronounced radial rows of beads.

The form recorded as a *Synedra* is very peculiar. It is extremely long and slender, with transverse rows of beads which are broken in the center by a blank space to form the pseudoraphe. One end is very decidedly spatulate, the other only slightly so.

Some time ago the theory was advanced that diatoms first entered fresh waters in the early Miocene and that the first species was *Melosira granulata*. This was founded upon the absence of any fossil diatoms in the Green River formation of Eocene age; conditions for their preservation seem ideal if any had even been present. In addition, the oldest deposits in western America which seem to be early Miocene, as determined by other fossils, contain only *Melosira granulata*.

If this theory is supported by sufficient additional evidence, then the successive appearance of other species should mark valuable points in the historical geology of fresh-water lakes.

A large amount of study of carefully collected and prepared material will be necessary to prepare such a diatom scale, but the results which would be

reaped by even partial success would amply justify the effort. By using the theory as a basis for speculation, it is evident that none of the three samples would fall in the early Miocene. The one noted as uppermost of the 275 lot has the fewest species and is the nearest to a pure culture of *Melosira granulata*, which in itself would suggest that it is oldest. Since, however, Mr. MacGinitie is certain that it actually is younger than the other 275 samples, there seems to have been a recurrent period or periods in the history of western lakes when *Melosira granulata* dominated the diatom flora.<sup>1</sup>

Although there is not yet sufficient evidence available to warrant definite statements as to the age of fresh-water deposits based upon the diatoms alone, it does seem that it is safe to say that none of the three samples submitted can be older than Pliocene (or upper Miocene at the earliest) if the theory regarding diatom invasion is justified. Also, because *Fragilaria* appears to have been a late arrival, the unmarked sample should be considerably younger than the other two.

### SUMMARY

The Trout Creek flora of southeastern Harney County, Oregon, is considered to be of upper Miocene age on the basis of its relation to the Mascall flora. The numerical dominants of the flora form an assemblage which is similar to the association composed of tan oak, madrone, Douglas fir and Port Orford cedar, now occupying the Klamath Mountain area of southwestern Oregon and northwestern California. This relationship indicates that the climate of the region occupied by the Trout Creek Miocene forest was cool-temperate with an annual rainfall approximating that which prevails in the Klamath Mountains today. The fossil plant community likewise furnishes evidence that its habitat was in a highland region. This Miocene forest resembles the living floral association of northeastern Asia, especially the flora of northern Japan and Manchuria, although these regions lack one of the important numerical dominants, the madrone.

<sup>1</sup> In this connection it should be noted that the upper diatomite beds contain but few fossil leaves. The tuffaceous sandstone bed which separates the two sections of the diatomite marks some change in the conditions of sedimentation which is not clearly understood. The lower beds contain abundant fossils and a rich diatom flora, while the upper strata bear an impoverished diatom flora and comparatively infrequent leaf impressions.  
H. D. M.

## SYSTEMATIC DESCRIPTIONS

## PHYLUM SPERMATOPHYTA

## CLASS GYMNOSPERMÆ

## ORDER CONIFERALES

## Family PINACEÆ

## Genus PINUS Linné

*Pinus knowltoni* Chaney

*Pinus knowltoni* Chaney, Walk. Mus. Contr., vol. 2, No. 5, 160, pl. 5, figs. 3, 4, 1920.

Needles of *Pinus* in fascicles of 3, which occur sparingly at the Trout Creek locality, are referable to this fossil species. *P. knowltoni* is fairly common in the Mascall flora, and has been compared to the living *P. attenuata* Lemm. by H. L. Mason.<sup>1</sup>

Collection—Univ. Calif. Coll. Pal. Bot., Nos. 548, 549.

## Genus PICEA Link

*Picea lahontense* new species

(Plate 3, figs. 4, 6, 8)

This species is founded on cones, seeds, twig fragments and a twig with three leaves attached.

*Description*—Leaves strongly ridged or angled, 2.5 cm. long, 2 mm. wide; jointed near the branch on the woody pegs characteristic of the genus; twigs marked by the woody pegs left by the fall of the leaves. Fruits with slender, pointed seeds and broad wing; length of fruit, 1 cm., width of wing, 4 mm. Cones elongate-oblong, length of cones from 7 to 12 cm., width from 3 to 3.5 cm., scales rounded or somewhat pointed, striated, edges crenulate.

No other species of *Picea* has been described from the Tertiary of North America on material which is specifically comparable to our species, although Mason<sup>2</sup> has described a twig from the Tipton, Oregon Mascall beds. The leaves, fruits and smaller cones have a close resemblance to those of the living *Picea engelmannii* Engelm. The larger cone figured is much larger than the average cone of *P. engelmannii*, and the cone scales are more rounded than is usual with that species; but both these characters are within the limits of variation among the cones of *P. engelmannii*. This cone has a marked resemblance to the cones of *Picea breweriana* Wats., *Picea asperata* Mast. or *Picea smithiana* Boiss., and may represent a separate species, although it is more probable that the fossil material is all from the same species and comparable to *P. engelmannii*.

*Picea engelmannii* is a typical tree of the Canadian Life-Zone. It ranges through the mountains of the northwest coast in British Columbia east to Alberta and southward to the extreme northern part of California and the high Rocky Mountains in northern Arizona. West of the fossil locality, in the southern Cascade Mountains of Oregon, it occurs in canyons and on

<sup>1</sup> Carnegie Inst. Wash. Pub. No. 346, 148, 1927.

<sup>2</sup> *Op. cit.*, 151.

damp slopes at altitudes of from 5600 to 8000 feet. In the Blue Mountains of northeastern Oregon it is plentiful above 3000 feet.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 550; Paratypes, Nos. 551, 552.

Genus PSEUDOTSUGA Carr.  
*Pseudotsuga masoni* new species

(Plate 3, figs. 1, 2, 3)

This genus is represented by numerous fruits and by fragments of twigs.

*Description*—Fruits with elliptical-obovate wing, cuneate at base; average length, 2 cm.; seed oval with pointed tip. Twigs with ovoid leaf-scars and decurrent ridges.

The writer has no knowledge of any reference to the occurrence of *Pseudotsuga* fruits in the Tertiary of North America. Penhallow named *Pseudotsuga miocena*<sup>1</sup> from wood found in the Eocene of Saskatchewan and the Miocene of British Columbia, and also reported *Pseudotsuga macrocarpa*<sup>2</sup> from the Pleistocene (?) of Orleans in northern California. Mason<sup>3</sup> has described *P. taxifolia* (Lamb.) Britt. from cone material in the Merced sandstones of coastal central California. Dorf describes cones from the Pliocene of northern California under the name of *P. sonomensis*.<sup>4</sup> Cones have recently been discovered by Mason in the Tertiary deposits of St. Lawrence Island in the Bering Sea.<sup>5</sup>

These fruits are practically identical with those of the present *P. taxifolia*, a large forest tree of the cool, moist Transition Life-Zone of the west coast from southern Oregon to British Columbia. This species also occupies a wide range of habitats in the mountains from British Columbia to central California and eastward from Montana to northern Mexico.

In view of the prevalence of *P. taxifolia* along stream-courses, its scarcity in the Miocene fossil record seems difficult to explain; it may be due partly to certain characteristics of the tree, such as its readily deciduous foliage, its fragile cones, and the resemblance of the fruits to those of *Pinus*. It is an excellent indicator of the Transition Life-Zone.

This species is named in honor of Dr. Herbert L. Mason of the Department of Botany at the University of California.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 553; Paratype, No. 554.

Genus ABIES Link  
*Abies laticarpus* new species

(Plate 3, fig. 5)

Seeds of *Abies*, similar to those of the living *Abies magnifica* Murr., the western red fir, are not uncommon in the Trout Creek beds. This is the first appearance in the fossil record of seeds definitely corresponding to *A. magnifica*. Mason<sup>6</sup> has identified fruits of *Abies magnifica* var.

<sup>1</sup> Roy. Soc. Canada Trans., ser. 2, vol. 8, sec. 4, 68, 1903; vol. 9, sec. 4, 47, figs. 12, 13, 1904.

<sup>2</sup> *Op. cit.*, vol. 10, sec. 4, 70.

<sup>3</sup> Carnegie Inst. Wash. Pub. No. 346, 151, 1927.

<sup>4</sup> Carnegie Inst. Wash. Pub. No. 412, 72, 1930.

<sup>5</sup> Oral communication, Aug. 10, 1932.

<sup>6</sup> Carnegie Inst. Wash. Pub. No. 346, 150, pl. 4, figs. 6, 7, 1927.

*shastensis* Lemm. from the John Day Basin. The fruits from Trout Creek have a much wider wing and more pointed seed than these.

The living species is common in the higher portions of the Cascade Mountains of southern Oregon, and thence southward into California in the Trinity and Salmon Mountains and along the high Sierra Nevada to the divide between the White and Kern Rivers.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 555; Paratype, No. 556.

### Family CUPRESSACEÆ

Genus *THUITES* Sternberg

*Thuites* sp. Knowlton

(Plate 3, fig. 7)

*Thuites* sp. Knowlton, U. S. Geol. Surv. Bull. 204, 26, pl. 1, fig. 3, 1902.

Fragments of branchlets referable to *Thuites* are plentiful in the upper part of the leaf quarry. *Thuja*, *Chamæcyparis* and *Cupressus* are difficult to separate on the basis of branchlets only. It is generally the case that in *Chamæcyparis* the leaves on the flattened side of the branch do not overlap, while in *Thuja* these leaves overlap and conceal the junction between the keel leaves. *Cupressus* may, in some instances, be separated by its different manner of branching and its more rounded branchlets. The specimen figured is like branchlets from the living *Thuja plicata* Don, although the delicate nature of the fronds and general appearance of the branchlets show a closer correspondence to *Chamæcyparis* than to *Thuja*. It is possible that both genera are represented, but the evidence favors the reference of the fossil leaves to *Chamæcyparis*.

*Collection*—Univ. Calif. Coll. Pal. Bot., Plesiotype, No. 559.

## CLASS ANGIOSPERMÆ

### SUBCLASS MONOCOTYLEDONEÆ

#### ORDER PANDANALES

##### Family TYPHACEÆ

Genus *TYPHA* Linné

*Typha lesquereuxi* Cockerell

*Typha lesquereuxi* Cockerell, Bull. Torr. Bot. Club, vol. 33, 307, 1906.

The leaves of *Typha* are fairly plentiful and well preserved.

*Collection*—Univ. Calif. Coll. Pal. Bot., No. 641.

#### ORDER ARALES

##### Family ARACEÆ

Genus *LYSICHITON* Schott

*Lysichiton nevadensis* new species

(Plate 7, fig. 4)

This impression represents the mature spadix of an aroid. The surface shows the crowded, four-lobed perianths, about 4 mm. in diameter, with a central umbilicus marked by radiating depressions. It is more closely allied to the present *Lysichiton kamtschaticense* (L.) Schott than any of

the other aroids. Berry has recently described *L. washingtonense* from the Grand Coulee Flora,<sup>1</sup> but the specimen figured there is quite different, with much smaller flower segments. It may be an immature spadix.

The present species is common in cool, swampy meadows along the coast from California to Alaska. Its presence is to be expected in fossil material from the borders of a shallow lake.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 558.

## ORDER LILIALES

### Family LILIACEÆ

Genus SMILAX Linné

*Smilax magna* Chaney

*Smilax magna* Chaney, Walk. Mus. Contr., vol. 6, No. 5, pl. 6, fig. 1, 1920.

The Eagle Creek species is represented in the Trout Creek collection by a large leaf with the characteristic expanded, almost auriculate base. It has been compared to the living *S. hispida* Muhl. but is more like *S. tamnoides* L. of the southeastern states, or *S. acutifolia* Schl. of the Mexican Sierra Madre.

*Collection*—Univ. Calif. Coll. Pal. Bot., No. 559.

## SUBCLASS DICOTYLEDONEÆ

### ORDER SALICALES

#### Family SALICACEÆ

Genus SALIX Linné

*Salix* sp. Knowlton

*Salix* sp. Knowlton, U. S. Nat. Mus., vol. 51, 260, pl. 13, figs. 4, 5, 1916.

Several leaves of *Salix* appear to be identical with the figured specimens of *Salix* sp. Knowlton from the Miocene at Florissant. Among the living species they show the nearest relationship with *Salix hindsiana* Benth., which grows along streams and in swampy places from the higher Sierra Nevada to the foothills.

*Collection*—Univ. Calif. Coll. Pal. Bot., No. 560.

Genus POPULUS Linné

*Populus lindgreni* Knowlton

*Populus lindgreni* Knowlton, U. S. Geol. Surv. 18th Ann. Rept., part 3, 725, pl. 100, fig. 5, 1898.

Only two leaves referable to this genus are in the Trout Creek material. They are similar to *P. tremuloides* Michx. (*P. aurea* Tidestrom), having the characteristic venation and suborbicular outline. In the work cited there is confusion in the comparison of fossil *Populus* with living species. *Populus eotremuloides* Kn. is compared to the living *P. tremuloides*, but the figure is more characteristic of *P. tricocarpa* Hook. or *P. balsamifera* L. *Populus lindgreni* is compared to *P. balsamifera*, but the figure closely approximates a leaf of *P. tremuloides*. Since the figure seems to have taken preference over Knowlton's written comparison, the leaves from Trout Creek, comparable to *P. tremuloides*, are referred to *P. lindgreni*. Knowlton in a later paper<sup>2</sup> figures a leaf similar to *P. tremuloides* as *P. lindgreni*.

<sup>1</sup> U. S. Geol. Surv. Prof. Paper 170-C, 35, pl. 11, fig. 2, 1931.

<sup>2</sup> U. S. Geol. Surv. Bull. 204, 29, pl. 11, fig. 1, 1902.

## ORDER JUGLANDALES

## Family JUGLANDACEÆ

## Genus JUGLANS Linné

*Juglans oregoniana* Lesquereux

*Juglans oregoniana* Lesquereux, Mus. Comp. Zool. Mem., vol. 6, 35, pl. 9, fig. 10, 1878.

*Juglans hesperia* Knowlton, U. S. Geol. Surv. 18th Ann. Rept., part 3, 723, pl. 99, fig. 8, 1898.

This typical Mascall species is represented by a single leaflet, very like the one figured by Knowlton. It is closer to the present *Juglans nigra* L. than to either of the western species of the genus, *J. hindsii* Jepson or *J. californica* Wats. These latter species inhabit stream-bottoms in the central valleys of California and coastal southern California.

Collection—Univ. Calif. Coll. Pal. Bot., No. 563.

## ORDER FAGALES

## Family BETULACEÆ

## Genus CARPINUS Linné

*Carpinus grandis* Unger

*Carpinus grandis* Unger, Synop. Pl. Foss., 220, 1845.

A characteristic leaf and an incomplete fruit confirm the presence of *Carpinus* in the Trout Creek flora. This species of *Carpinus* is common in the Crooked River flora and it has been named from several Tertiary floras. Chaney has questioned the reference of the American fossil to the species *grandis*.<sup>1</sup> Whatever the final specific reference may be, it is evident that the Trout Creek and Crooked River species are the same. The fossil species most closely resembles the oriental *Carpinus laxiflora* Blume.

Collection—Univ. Calif. Coll. Pal. Bot., Nos. 564, 565.

*Betula lacustris* new species

(Plate 4, figs. 2, 3, 4)

*Description*—Leaves ovate, length 5 to 10 cm., width 4 to 6 cm.; apex acuminate, base cuneate to broadly cuneate, sometimes asymmetric; margin, except for about 1 cm. on either side of the petiole where it is entire, sinuate-serrate with forward-pointing teeth; petiole slender, curved, 3 cm. long; midrib straight or slightly curved at the point of attachment of the secondaries, somewhat divergent, the lower secondaries down-curved at the point of attachment to the midrib; angle with midrib in the central part of the leaf, 40°; secondaries craspedodrome into the large marginal teeth; tertiaries irregularly percurrent to reticulate, the cross-ties bowed outward toward the margin; areolation fine-polygonal; texture membranaceous.

There is no well-marked character which will serve to differentiate the leaves of *Alnus* from those of *Betula*. The result has been a great deal of confusion in the assignment of fossil forms among these genera. Chaney has discussed this matter for some of the forms of the Tertiary of central Oregon.<sup>2</sup> The great majority of the figured leaves of *Betula* from the

<sup>1</sup> Carnegie Inst. Wash. Pub. No. 346, 106, 1927.

<sup>2</sup> Carnegie Inst. Wash. Pub. No. 349, 9, 1925.



Bridge Creek and Latah floras could, with equal propriety, be assigned to *Alnus*. Many hundreds of betulaceous leaves were examined by Chaney in his study of the Bridge Creek floras, none of which agree in character with the Trout Creek species.<sup>1</sup> The general shape of margin of *Betula largei* Knowlton figured on plate 50 of U. S. Geol. Survey Professional Paper 154 is similar to the leaves from the Trout Creek beds, but the percurrent tertiary venation indicated is quite different.

There is a group of contrasting leaf characters among species of *Alnus* and *Betula* which facilitate a correct determination if the leaf is completely preserved, although any one of these characters may be invalid in a particular case. In *Alnus* there is a greater tendency to percurrency in the tertiary veins, the apex is more acute than acuminate, the marginal serrations are generally finer, the lower secondaries make a wider angle with the midrib, and the abaxial tertiary branches to the margin are more direct and better defined when compared to the leaves of *Betula*. The alders which inhabit the Upper Canadian Life-Zone, such as *A. tenuifolia* Nutt. and *A. sinuata* Rydb., have leaves much like those of birch and it is extremely difficult, if not impossible, to make a satisfactory separation of the genera by means of foliar characters when this type of alder leaf is involved. Determinations made by means of imperfect fossil leaves are always open to question. Applying the criteria outlined above to the betulaceous leaves from the Trout Creek formation, it seems evident that many of them are referable to *Betula* rather than to *Alnus*, and the presence of seeds and cone scales of *Betula* helps to verify this conclusion. A few of the leaves are clearly *Alnus*, but some of them are indeterminate; they might be assigned to either genus.

The *Betula* leaves figured resemble those of *Betula papyrifera* var. *occidentalis* Sarg., which ranges from southwestern British Columbia, south and east through Washington, northern Idaho and Montana west of the continental divide. They are also similar to the leaves of *Betula fontinalis* Sarg. which is widely distributed in the western mountains from Saskatchewan to northern New Mexico, and from the northern cross-ranges of California to the eastern foothills of the Rocky Mountains.

These modern birches are members of the Canadian Life-Zone flora and grow in damp ground on the edges of mountain meadows, along stream-banks, or around lakes. At the northern limit of their range they grow at low elevations; southward they are found only in the mountains.

Collection—Univ. of Calif. Coll. Pal. Bot., Holotype, No. 566; Paratypes, Nos. 567, 568, 569, 570.

#### Genus *ALNUS* Hill

*Alnus carpinoides* Lesquereux

(Plate 4, fig. 1)

*Alnus carpinoides* Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 8, 243, pl. 50, fig. 11; pl. 51, figs. 4, 4a, 5, 1883.

The specimen figured is a twig with 6 mature cones attached. The cones are from 1.5 to 2 cm. long and from 6 to 10 mm. in diameter. No exact specific reference to living alders is possible on the basis of the cones only. The associated leaves are similar to those of the living *Alnus sinuata* Rydb. and *Alnus tenuifolia* Nutt., and the small size of the cones is a character

<sup>1</sup>Oral communication, July 22, 1932.

common to both of these species. The relationship to *Alnus tenuifolia* seems to be the most marked. This latter species is the common alder along mountain streams of the northern interior of the continent, and it is abundant on the east slopes of the Cascades and Sierra Nevada. *Alnus sinuata* is a subalpine species which grows in western North America from the borders of the Arctic Circle to the high mountains of northern California.

Chaney has discussed the relationship of *Alnus carpinoides* to living species<sup>1</sup> and has shown the close resemblance between the fossil species and *A. sinuata* and *A. tenuifolia*. The Trout Creek species is assigned to *Alnus carpinoides* on the basis of this similarity.

Collection—Univ. Calif. Coll. Pal. Bot., Plesiotype, No. 571; Nos. 639, 640.

### Family FAGACEÆ

Genus QUERCUS Linné

*Quercus consimilis* Newberry

(Plate 5, fig. 5)

*Quercus consimilis* Newberry, U. S. Geol. Surv. Mon. 35, 78, pl. 43, fig. 6, 1898.

*Quercus simplex* Newberry, U. S. Geol. Surv. Mon. 35, 71-72, pl. 43, figs. 2 to 5, 1898.

Thousands of leaves of this species have been taken from the quarry, and with this material available it is clear that *Quercus consimilis* was a variable species whose leaves show all gradations from entire-margined forms to those which are regularly serrate in the upper two-thirds of the leaf. The modern *Quercus myrsinæfolia* Blume,<sup>2</sup> common in the hilly country of Japan and eastern China, seems to be identical in foliar characters with the fossil species. The living species shows the slender petiole, characteristic venation, and the same range of variation in shape and margin. These are by far the commonest leaves at the locality, making up about three-fourths of all those found.

Collection—Univ. Calif. Coll. Pal. Bot., Plesiotypes, Nos. 572, 573, 575, 576; No. 574.

### *Quercus klamathensis* new species

(Plate 5, fig. 3)

*Description*—Leaves elliptical to ovate-lanceolate; apex acute or obtuse; base rounded or broadly cuneate; length 10 cm., width 3.5 cm.; petiole stout, short, about 1 cm. long; midrib heavy; 16 pairs of secondaries, subopposite, making an angle of 55° in the central part of the leaf which increases to 70° or more near the base, craspedodrome to the marginal dentations, sometimes bifurcating about half the distance toward the margin; tertiaries irregularly percurrent; finer veins forming a strong network; margin dentate; texture coriaceous.

This species has some resemblance to *Quercus horniana* Lesq.<sup>3</sup> and to *Quercus idahoensis*<sup>4</sup> Knowlton although it can not be the same, since the margin and type of venation are quite different. It does not correspond with any of the figured specimens of fossil oak leaves from the western Tertiary which have come to the writer's attention.

<sup>1</sup> Carnegie Inst. Wash. Pub. No. 349, 8-10, 1925.

<sup>2</sup> See sheets Nos. 356080, 259056 and 281850 in the herbarium of University of California.

<sup>3</sup> Lesquereux, Proc. U. S. Nat. Mus., vol. 11, 17, 1888.

<sup>4</sup> Knowlton, U. S. Geol. Surv. 18th Ann., Rept. pt. 3, 729, pl. 102, fig. 4, 1898.

The fossil leaves are very close to leaves from the living *Lithocarpus densiflora* (H. & A.) Rehd. (tan oak) of the west coast. There are no essential differences to be detected between the living and fossil leaves, and there can be no doubt that the fossil represents the direct Tertiary ancestor of the modern tan oak. It is gratifying to find these leaves in company with those of its modern associate the madrone (*Arbutus*). *Lithocarpus* is confined to western America and eastern Asia. Only one species grows in America, but a half-dozen or more species have been recorded from eastern Asia. The American species grows in the Coast Ranges of southwestern Oregon, in the California Coast Ranges as far south as Santa Barbara County, and in the mountains of northern California and down the west slope of the Sierras as far as Placer County. It is a close associate of the redwood and reaches its best development at the north around the edge of the redwood belt. It is a valuable indicator of the Middle Transition Life-Zone.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 577; Paratype, No. 578.

*Quercus simulata* Knowlton

(Plate 6, fig. 2)

*Quercus simulata* Knowlton, U. S. Geol. Surv. 18th Ann. Rept., part 3, 728, pl. 102, figs. 1, 2, 1898.

*Quercus simulata* Knowlton, emended, U. S. Geol. Surv. Prof. Paper 154, 246, pl. 51, figs. 6, 7, 9-11, 1928.

Leaves referable to this species occur in association with the *Q. consimilis* Newb. type. There appear to be all gradations between the two species and the difficulty of drawing well-marked specific lines between them is increased by the abundance of material. The specimens figured by Berry in Professional Paper 154 are close to the entire or sparingly toothed forms of *Q. consimilis*, but the characteristic tertiary venation and areolation are not reproduced, so that no final decision is possible. From the evidence available the writer is of the opinion that these two species, *Q. consimilis* and *Q. simulata*, are not distinct.

*Collection*—Univ. Calif. Coll. Pal. Bot., Plesiotype, No. 579.

*Quercus traini* new species

(Plate 5, figs. 1, 2)

*Description*—Leaves elliptic; dimensions of larger specimens: length 6 to 7 cm., width 2.8 to 3.2 cm.; apex acute; base cuneate to rounded cuneate; margin entire or dentate in the upper two-thirds of the leaf, the teeth triangular and usually pointing upward, irregularly disposed and of variable size; petiole stout, 5 mm. to 1 cm. long; midrib stout, tapered to apex, straight or slightly curved; about 11 pairs of well-defined subopposite secondaries, somewhat irregular as to course, spacing and angle with midrib, angles vary from 45° to 80°, average 65°; the secondaries often separated into two equal branches at varying distances from the margin, or two secondaries may diverge from nearly the same point of attachment on the midrib, camptodrome where the margin is entire, branching and forming a series of loops near the margin, irregularly branching and craspedodrome where the margin is dentate, each branch entering a tooth; tertiary venation

irregularly percurrent or with reticulate areas; nervilles forming a fine quadrangular mesh; texture coriaceous.

The characters of these fossil leaves are so closely duplicated by similar characters in the living *Quercus chrysolepis* Liebm. as to establish a near relationship or absolute identity between them. The material is well preserved; in some cases the most delicate tracteries of venation are visible. A series of entire to variously dentate forms is present.

The great variability of the leaves of *Quercus* renders an exact comparison with figured specimens extremely difficult. In the group of specimens from Trout Creek are forms which might be compared with several different fossil species, such as *Quercus hannibali* Dorf,<sup>1</sup> *Quercus convexa* Lesquereux,<sup>2</sup> certain forms of *Quercus clarnensis* Trelease,<sup>3</sup> *Quercus treleasii* Berry<sup>4</sup> and *Quercus transgressus* Lesquereux.<sup>5</sup> *Quercus hannibali* was compared by Dorf to the living *Quercus chrysolepis* which is so like the fossil species here described. It is possible that the Trout Creek specimens should be referred to the species *hannibali*, since the differences between the fossil leaves are no greater than those among the leaves of *Q. chrysolepis*, but the forms figured are so different that it seemed best to establish a new species. The same leaf form occurs in the Payette formation.<sup>6</sup>

*Quercus chrysolepis* grows on mountain slopes and canyon sides in southern Oregon and southward throughout California. Its most favored habitat is along the canyon slopes in the lower Transition Life-Zone of the western Sierra Nevada and the northern Coast Ranges inland. The fossil species is named in honor of Mr. Percy Train, who has collected a large part of the material described in this paper.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 580; Paratypes, Nos. 581, 582, 583.

## ORDER RANALES

### Family RANUNCULACEÆ

#### Genus CLEMATIS Linné

#### *Clematis reticulata* new species

(Plate 6, fig. 4)

*Description*—Leaf ovate; length 6 cm., width 2.5 cm.; apex fragmentary; base cuneate, asymmetrical; margin entire, undulate; petiole not preserved; midrib straight, evenly tapered to apex; secondary venation looped-reticulate. A subprimary leaves the base on the wider side at an angle of 30° and is camptodrome, looping back to join the secondary next above; each strong secondary leaves the midrib at an angle of from 40° to 50°, branches a little more than half the distance out from the midrib and forms anastomosing loops with secondary branches which form a finer series of loops near the margin. The tertiaries, together with weak intersecondaries make up the network of coarse polygonal meshes roughly aligned with the secondaries. Texture membranaceous.

<sup>1</sup> Carnegie Inst. Wash. Pub. No. 412, 86, pl. 8, figs. 8-11, 1930.

<sup>2</sup> Mus. Comp. Zool. Mem. Harvard Univ., vol. 6, No. 2, 4, pl. 1, figs. 13-17, 1878.

<sup>3</sup> Carnegie Inst. Wash. Pub. No. 346, pl. 10, fig. 11, 1927.

<sup>4</sup> U. S. Geol. Surv. Prof. Paper 154, 247, pl. 52, figs. 1-3, 1928.

<sup>5</sup> Lesquereux, Mem. Harvard Mus. Comp. Zool. vol. 6, No. 2, 59, 1878.

<sup>6</sup> Chaney, Amer. Jour. Sci. vol. 4, 219, 1922.

This description is founded on a single, finely preserved impression. There is no previous record of *Clematis* in the Tertiary of North America. The specimen greatly resembles *Clematis viorna* L. (plate 6, fig. 3), which is common along stream-banks in the middle Appalachians up to altitudes of 4000 feet. It is also comparable to *Clematis crispa* L. which is found in marshy habitats from Pennsylvania to Missouri and southward to Arkansas and Texas. *Clematis fusca* Turczaninow, a native of Manchuria, Korea, Japan and northeastern China, also has a close resemblance to the fossil species.

The genus *Clematis* contains about 150 species and is abundant and widely distributed in the north temperate regions. North America has about 20 species and eastern Asia about 80.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 584.

### Family BERBERIDACEÆ

Genus *ODOSTEMON* Rafinesque

*Odostemon hollicki* Dorf

(Plate 7, figs. 1, 3, 5)

*Odostemon hollicki* Dorf, Carnegie Inst. Wash. Pub. No. 412, 93, pl. 10, figs. 7, 8, 1930.

The species described from the California Pliocene by Dorf seems to be identical with that from Trout Creek. Both species are little different from the present *Odostemon aquifolium* (Pursh) Rydb. which is a common plant of the cool, coastal Transition Zone of California, Oregon and Washington. The only other comparable living species is *Odostemon nervosa* (Pursh) Rydb. which has more numerous marginal teeth and a better developed palmate venation.

*Collection*—Univ. Calif. Coll. Pal. Bot., Plesiotypes, Nos. 585, 586, 587.

*Odostemon simplex* (Newberry) Cockerell

(Plate 9, fig. 1)

*Odostemon simplex* (Newb.) Cockerell, Amer. Mus. Nat. Hist. Bull. vol. 24, 91, 1908.

Well-preserved leaves of this species occur more rarely than those of *O. hollicki* Dorf. Enough material is at hand to render certain the fact that two separate species of *Odostemon* existed in the Trout Creek flora.

*Collection*—Univ. Calif. Coll. Pal. Bot., Plesiotype, No. 588; No. 589.

### Family NYMPHÆACEÆ

Genus *NYMPHÆA* Linné

*Nymphæa diatoma* new species

(Plate 7, fig. 6; plate 8, fig. 1)

The abundance of *Nymphæa* is proved by the remains of rootstocks and leaves. The leaves are somewhat fragmentary, but the rootstock impressions are well preserved.

*Description*—Leaves cordate-reniform; 14 cm. broad; apex obtuse or rounded; base cordate, with a wide, V-shaped sinus whose margins are

nearly straight or slightly rounded at the base; margin entire; petiole stout, preserved for 3.5 cm.; venation palmate with a stout midrib which gives off several secondaries; primaries and secondaries from the midrib branching fan-wise, proceeding tortuously toward the margin and branching repeatedly in the periphery of the leaf; tertiary venation not preserved; texture membranaceous.

Rootstocks with irregular polygonal scales; these scales with groups of four or five rounded or ovoid petiole scars, from 1 to 5 mm. in diameter.

The texture and venation of the leaf show it to be quite distinct from *Nymphæa polysepala* Greene and *N. advena* Soland. of the western states and Canada. It is similar to the leaves of the common eastern pond lily, *Nymphæa odorata* Ait., which is distributed from southern Canada through the eastern and central states to the borders of the Gulf of Mexico. This species thrives in shallow lakes with rich bottom soil and free exposure to the sun.

The rootstock fossils seem to be the same impressions which Knowlton figured from Esmeralda flora and described as an unknown plant.<sup>1</sup> In a recent paper, Depape describes and figures smiliar fossils of *Nelumbium* and *Nymphæa* from the Tertiary of western Europe.<sup>2</sup>

Collection—Univ. Calif. Coll. Pal. Bot., Holotype, No. 590; Paratype, No. 591.

## ORDER ROSALES

### Family ROSACEÆ

#### Genus SPIRÆA Linné

##### *Spiræa* (?) sp.

(Plate 9, fig. 1)

*Description*—Leaf oblong-ovate; length 4.4 cm., width 1.5 cm.; apex slender-obtuse; base cuneate; petiole fragmentary, slender, 3 mm. long; margin entire in the lower half or two-thirds, the upper part coarsely dentate with a few forward pointing teeth; midrib stout but somewhat irregular and tapered to a fine thread at the apex; about eight pairs of alternate or subopposite secondaries at an angle of 45° in the middle part of the leaf, 50° to 60° apically, curving upward and camptodrome where the margin is entire and entering the teeth above; tertiaries more plentiful toward the margin of the leaf, at right angles with the secondaries; areolation fine polygonal; texture subcoriaceous.

There is no record of *Spiræa* from the Tertiary of western North America.

This leaf is very close to the leaves of *Spiræa douglasii* Hook. (plate 9, fig. 2), which is a common shrub in the coastal Transition Zone of northern California and Oregon. It may also be compared with *Spiræa idahoensis* A. Nels, a closely related species which grows in the Transition Zone of the higher Idaho mountains and with *Spiræa menziesii* Hook., found in cold marshes from Alaska to the higher portions of Oregon.

The genus is questioned since there is only one leaf and the apex is imperfect.

Collection—Univ. Calif. Coll. Pal. Bot., Holotype, No. 592.

<sup>1</sup> U. S. Geol. Surv. 21st Ann. Rept., part 2, 212, pl. 30, figs. 16, 24, 25, 1901.

<sup>2</sup> Bulletin Géologique et Minéralogique de Bretagne, Tome 5, fasc. 1, 43-44, pl. 5, 1924.

## Genus ROSA Linné

*Rosa hilliae* Lesquereux

*Rosa hilliae* Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 8, 199, pl. 40, figs. 16, 17, 1883.

There is a complete leaf of *Rosa* in the collection of Percy Train, having five leaflets, which is referred to the common Mascall species. Chaney has discussed the affinities of *Rosa hilliae* in his paper on the Crooked River flora.<sup>1</sup> As there used, the species is probably a composite one, since there is no more reason to believe that only one species of *Rosa* grew along the streams in Miocene time than that such would be the case today.

The leaf mentioned is similar to the leaves of *Rosa nutkana* Presl., which is common in thickets by streams in northern California to Alaska and eastward to Utah. The same plant today forms luxuriant thickets along the banks of Trout Creek.

Collection—Univ. Calif. Coll. Pal. Bot., No. 638.

## Genus SORBUS Linné

*Sorbus alvordensis* new species

(Plate 9, fig. 4)

*Description*—Leaves pinnately compound; length 6 cm., width 1 cm.; leaflets lanceolate; margin serrate, with triangular forward-pointing teeth; apex acute; base narrow cuneate, usually asymmetric, sessile; midrib well defined; 12 or more pairs of closely spaced, subopposite secondaries, leaving the midrib at an angle of about 70°, but curving upward and ascending along the margin, branching and craspedodrome to the teeth; tertiaries obscure, apparently forming a fine, reticulate network; texture membranaceous.

Three species of *Sorbus* were described by Cockerell from the Florissant Beds; one of these, *Sorbus megaphylla*,<sup>2</sup> has some resemblance to the Harney County specimens, but the shape, size and marginal serrations are so different as to make it unlikely that the species are the same.

These leaves are well matched by leaves of *Sorbus sitchensis* Roem (*sambucifolia*) (plate 9, fig. 3) and also by leaves of the Asiatic *S. hupehensis* Schneider. These are both high altitude plants, native of the Canadian or Hudsonian Life-Zone. *S. sitchensis* grows at altitudes of from 5000 to 9000 feet in California and is common on steep slopes above streams; *S. hupehensis* occupies similar situations in the mountains of northwest China, especially in Kansu province.

The genus *Sorbus* contains about 80 species distributed throughout the northern hemisphere, generally in the cooler and higher regions. *S. americana* Marsh. is found as far south as the mountains of North Carolina.

*Occurrence*—Trout Creek Formation, locality No. 275, Alvord Creek Beds, north of the south fork of Alvord Creek, Locality 601.

Collection—Univ. Calif. Coll. Pal. Bot., Holotype, No. 593.

## Genus CRATÆGUS Linné

*Cratægus gracilens* new species

(Plate 9, fig. 6)

*Description*—Leaves oval to obovate; maximum length 8 cm., maximum width 5.5 cm.; apex acute or acuminate, base narrowly to broadly cuneate;

<sup>1</sup> Carnegie Inst. Wash. Pub. No. 346, 123, 1927.

<sup>2</sup> Amer. Mus. Nat. Hist. Bull., vol. 24, 95, pl. 9, fig. 29, 1908.

margin serrate, except the entire base, and divided or incised into four to six short acute lobes on each side; petiole slender, 2 cm. long; midrib slender, tapered to the apex; 6 to 8 pairs of secondaries at angles of  $45^{\circ}$  with the midrib, craspedodrome to the serrations, other tertiaries are irregularly percurrent in the upper part of the leaf or reticulate near the base, their general course at right angles to the midrib, areolation fine polygonal; texture membranaceous.

No fossil leaves similar to the specimen from Trout Creek have been figured from the Tertiary of North America. *Cratægus imparilis* Knowlton from the Mascall of the John Day Basin<sup>1</sup> and *Cratægus newberryi* Cockrell<sup>2</sup> are both of quite different leaf types when compared to our species.

In view of the over-multiplication of botanical species in the genus *Cratægus*, any suggestion of resemblance to living species on the basis of leaf form may be unwarranted; however, there are similarities worth noting. *Cratægus piperi* Britt., a plant of the mountains of Idaho and eastern Oregon and Washington, is very like the fossil form in venation and shape of margin; *C. coccinea* L. which grows from Montana and Colorado eastward to New Hampshire and Virginia, is also close to the fossil species. *C. douglasii* Lindl. grows along streams in the Klamath Mountains of southwest Oregon and northern California, and although its leaves are variable, some of the forms are similar to the Trout Creek species. The genus is widely distributed in the temperate regions of the Northern Hemisphere and has its greatest development in North America.

Collection—Univ. Calif. Coll. Pal. Bot., Holotype, No. 594; Paratype, No. 595.

#### Genus AMELANCHIER Medicus

##### *Amelanchier grayi* Chaney

*Amelanchier grayi* Chaney, Carnegie Inst. Wash. Pub. No. 346, 120, pl. 14, figs. 3-5, 1927.

*Amelanchier scudderii* Cockerell, Prof. Paper 154, U. S. Geol. Surv., 252, pl. 55, fig. 4, 1928.

There are four leaves from the Trout Creek locality which are closely similar to the leaves of the living *Amelanchier alnifolia*. The species has been described by Chaney and by Berry, each emphasizing a likeness with the modern *A. alnifolia*.

*A. scudderii* from the Florissant Beds was established on a single, incomplete specimen which Cockerell also compared with *A. alnifolia*. In view of the unsatisfactory preservation of the type specimen of *A. scudderii* and its wide geographic separation from the Oregon material, the writer accepts the name *grayi*, established by Chaney in 1927 on adequate material. *A. scudderii* may be the same species, but no definite conclusion may be reached. The Trout Creek forms are clearly the same species as that described by Chaney and by Berry, as indicated in the above synonymy.

Berry has described the range and habitat of the living species fully. It is very common on the mountains of southern Oregon, particularly in the Cascades, west of the fossil locality.

The leaves from Trout Creek are larger than those normally found on the western *A. alnifolia*. This is probably a response to edaphic and climatic factors of the habitat. Leaves of this type (sometimes called *A. oreophila* A. Nels) are found on specimens from deep canyons on the west slopes of

<sup>1</sup> U. S. Geol. Surv. Bull. 204, 66, pl. 10, fig. 2, 1902.

<sup>2</sup> Univ. Colorado Studies, vol. 5, 43, 1908.



the Rocky Mountains in Montana, Colorado and Idaho. These plants are definitely *A. alnifolia* and not worthy of the rank of a separate species.

*Amelanchier grayi* (?) flower

*Description*—Flower about 3 cm. in diameter, five-parted; petals absent; five sepals, oblanceolate, 1.2 cm. long with pronounced midvein and a weaker vein near each margin parallel to the midvein; receptacle flattened, originally cup-shaped or cone-shaped, with five major divisions, each major division again divided into two equal parts by a longitudinal indentation; the summit of the receptacle forming an irregular flat ring with peripheral scars probably formed by the detachment of the petals and stamens; pistils absent.

This fossil represents a flower with a five-merous perianth, perigynous stamens, and carpels adnate to the surface of a deep, cup-like axis. It is almost certainly a member of the Rosaceae and is similar to mature flowers of the genus *Amelanchier*.

*Collection*—Univ. Calif. Coll. Pal. Bot., Nos. 596, 597, 598.

Family SAXIFRAGACEÆ

Genus HYDRANGEA Linné

*Hydrangea bendirei* (Ward) Knowlton

*Hydrangea bendirei* Knowlton, Calif. Univ. Dept. Geol. Bull., vol. 2, 309, 1901.

The material from Trout Creek contains an impression of a sterile flower of this species with four sepals. There is some doubt as to the correct generic reference of this fossil.<sup>1</sup> The absence of small flowers within the involucre favors its reference to *Hydrangea* rather than to *Cornus*. It has been found in the Latah flora and at the Van Horn's Ranch Mascall locality.

*Collection*—Univ. Calif. Coll. Pal. Bot., No. 599.

Family LEGUMINOSÆ

Genus LEGUMINOSITES Bowerbank

*Leguminosites* sp.

(Plate 9, fig. 7)

*Description*—Legumes 5 cm. in length, 7 mm. in width; slightly curved, flattened; showing from 10 to 12 enclosed seeds.

These pods can not be assigned to any one genus of the Leguminosæ with certainty. They resemble the legumes of *Cassia absus* L. or *Galactia pilosa* Ell, but they may belong to some of the herbaceous genera, such as *Lathyrus*, the pods of which are very similar and which is a more likely genus to occur as a member of the association.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 600.

ORDER GERANIALES

Family RUTACEÆ

Genus PTELEA Linné

*Ptelea miocenica* Berry

(Plate 11, fig. 1)

*Ptelea miocenica*, Berry, U. S. Geol. Surv. Prof. Paper 170, 39, pl. 12, fig. 7, 1931.

This species has recently been described by Berry from the Grand Coulee, Washington. It is represented in the Trout Creek material by a samara of

<sup>1</sup> Knowlton, U. S. Geol. Surv. Bull. 204, 61, 1902; also Chaney, Carnegie Inst. Wash. Pub. No. 346, 131, 1927.

the same size and a portion of a trifoliate leaf. The leaf is close to that of *P. trifoliata* L. Its preservation does not warrant a separate description at this time.

*Ptelea trifoliata* is widely distributed in the central and eastern states, from eastern New Mexico north through eastern Colorado, northeast to southern Minnesota and eastward to southern New York, occupying all the area to the south and east except the lowlands of the Gulf and South Atlantic states. It is occasionally a small tree, but is more often a shrub which inhabits well-drained, rocky situations on the edges of the forest.

Another similar species, *Ptelea baldwinii* T. & G., is found in the mountains of Mexico and Arizona, and its variety, *crenulata*, grows in the Upper Sonoran Life-Zone of California in the Sierra Nevada foothills and inner Coast Ranges.

Collection—Univ. Calif. Coll. Pal. Bot., Plesiotype, No. 601; No. 602.

## ORDER SAPINDALES

### Family SAPINDACEÆ

#### Genus SAPINDUS Linné

#### *Sapindus affinis* Newberry (?)

*Sapindus affinis* Newb., N. Y. Lyc. Nat. Hist. Ann., vol. 9, 51, 1868.

Only one specimen of *Sapindus* has been found in the Trout Creek deposit. This consists of three fragmentary, but well-preserved leaflets, which so closely correspond to the figure and description of *S. affinis* that they are tentatively referred to that species. The fossil leaves are similar to leaflets of *Sapindus drummondii* H. & A., which now grows in the central and southern states and westward and southward to the mountain valleys of Arizona and northern Mexico.

Collection—Univ. Calif. Coll. Pal. Bot., No. 619.

### Family CELASTRACEÆ

#### Genus EUONYMUS Linné

#### *Euonymus* (?) *montana* new species

(Plate 11, fig. 7)

*Description*—Leaf ovate or slightly obovate; length 10.5 cm.; width 4.8 cm.; apex not preserved; base cuneate; margin entire at the base, indistinct above; petiole stout, 1.4 cm. long; midrib stout at base, tapered to a fine thread at the apex; 7 or 8 pairs of subopposite secondaries making an angle of about 55° with the midrib near the base, 40° near the apex, straight near the midrib, but soon becoming branched and sinuous, curving upward along the margin where they become much attenuated, branched and forming anastomosing loops along the margin; tertiaries thin, variable; a few entire cross-ties, but mostly reticulate and forming an open polygonal network.

No comparable fossil species have been described from the Tertiary of North America.

The fossil is much like the leaves of *Euonymus atropurpureus* Jacq., which is abundant in the central and eastern states and grows as far north and west as the mountains of western Montana.

*E. occidentalis* Nutt., found along mountain streams from Puget Sound to California, shows several points of difference. *E. atropurpureus* grows in cool shady woods along streams, but has a rather wide range of habitat.

*Euonymus* has about 120 species in the northern hemisphere; the largest number of which are in eastern and central Asia. North America has four common species; one confined to the west coast, the other three in the eastern and central states.

This species is questioned because the margin of the holotype leaf is imperfect and it is not certain that it is serrate.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 603.

## Family ACERACEÆ

Genus ACER Linné

*Acer chaneysi* Knowlton

*Acer chaneysi* Knowlton, U. S. Surv. Prof. Paper 140, 45, pl. 27, fig. 2, 1926.

*Acer gigas* Knowlton, U. S. Geol. Surv. Bull. 204, 76, pl. 14, fig. 1, 1902.

The writer believes that the leaves named as *Acer chaneysi* and the fruits named as *Acer gigas* are both from the same species of maple similar to the living *Acer saccharinum* L. *A. chaneysi* was established on a single incomplete specimen which is similar to deeply dissected leaves of *A. saccharinum*. Berry<sup>1</sup> has since figured an apical lobe of the fossil species which is not distinguishable from corresponding portions of the leaves of the soft maple obtained from trees on the University of California campus. The figure of the type *Acer gigas* is like a large fruit of *A. saccharinum*. It is not uncommon to find the pointed fruits of the living maple from 6 to 7 cm. long, with the seed from 1.5 to 2 cm. in length. This is smaller than the type figured by Knowlton which is 9.5 cm. long, and the samara is usually more curved in the fruits of the living maple. Nevertheless, this fossil fruit is so similar to the characteristic fruits of *A. saccharinum* that there can be little doubt that it is from the Miocene equivalent of the living species. The material from Trout Creek contains leaves and fruits which help to confirm this similarity.

The present species grows along the sandy banks of streams or more rarely in swampy habitats, ranging from New Brunswick to western Florida and from southeastern South Dakota to eastern Oklahoma.

*Collection*—Univ. Calif. Coll. Pal. Bot., Nos. 611, 612.

*Acer merriami* Knowlton

(Plate 10, fig. 1)

*Acer merriami*, Knowlton, U. S. Geol. Surv. Bull. 204, 76, pl. 16, fig. 7, 1902.

*Acer oregonianum* Knowlton, U. S. Geol. Surv. Bull. 204, 75, pl. 13, figs. 5-8, 1902.

Leaves and fruits of *Acer* comparable to the present *Acer macrophyllum* Pursh are plentiful and often extraordinarily well preserved. *Acer macrophyllum* is extremely variable in foliar characters, having leaves with from three to seven lobes, nearly entire or variously dentate and more or less deeply dissected. The fossil leaves show a similar range of variation and in all ways seem to be identical with the living species.

*Acer macrophyllum* is common along streams throughout cismontane California and north to British Columbia and Alaska. It is rarely found in places where the rainfall is less than 25 inches. Its habit of growing on stream-banks with its limbs overhanging the water, accounts in part for the abundance of *A. merriami* in the fossil record.

<sup>1</sup> U. S. Geol. Surv. Prof. Paper 154, 256, pl. 63, fig. 13, 1928.

*Collection*—Univ. Calif. Coll. Pal. Bot., Plesiotype, No. 604; Nos. 605, 606, 607.

***Acer negundoides* new species**

(Plate 11, figs. 2, 3)

Fruits plainly referable to *Acer negundo* L. are common at the fossil locality. The habitat of the living tree along stream-beds and low, moist valley-bottoms, and its large production of seeds, make its preservation as a fossil certain wherever it is at all plentiful.

The present species, and its varieties, is found in moist situations under a wide range of temperature conditions from southern Canada to Mexico and throughout the United States from Vermont to Florida and westward to California and eastern Oregon.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 617; Paratype, No. 618.

***Acer osmonti* Knowlton**

*Acer osmonti* Knowlton, U. S. Geol. Surv. Bull. 204, 72, pl. 13, fig. 3, 1902.

There are several specimens which admirably illustrate the range of form in this species. It is convenient to tie in a fossil species with its modern equivalent, as has been done with *A. osmonti* by Chaney<sup>1</sup> in his comparison with *A. glabrum* Torr. When such a likeness has been satisfactorily established, it greatly facilitates identification of the fossil species, since a determination made by comparison with figures is sometimes questionable.

*A. glabrum* is a common plant of the upper canyons or moist and rocky mountain sides in the Upper Transition and Canadian Life-Zones, from the San Jacinto Mountains of California northward to Alaska and eastward to the west slopes of the Rocky Mountains.

*Collection*—Univ. Calif. Coll. Pal. Bot., Nos. 608, 609, 610.

***Acer scottiae* new species**

(Plate 12, fig. 4; plate 11, figs. 4, 8)

*Description*—Leaves of variable size, palmately five- to seven-lobed, the lobes commonly narrowed to a tapering point and separated by wide, rounded sinuses; the central lobe much the larger in the case of the smaller leaves and occasionally bearing two small lobules near the apex; base truncate or broadly cordate; the basal lobes strongly developed with outward-pointing or even down-curved points containing a well-marked craspedodrome primary, or reduced to blunt crenations containing a weak camptodrome primary; petiole rather slender, about half again as long as the central primary; margin entire, sometimes undulate.

Fruits of maple with the seeds truncated nearly at right angles; the samara short and wide, the back curved like a scimitar; total length of fruit 2.7 cm., width of samara 9 mm., seed 6 mm. in diameter.

The leaves are similar in shape and size to those figured as *Liquidambar europæum* Al. Braun in Monograph 35,<sup>2</sup> but lack the serrate margin. The

<sup>1</sup> Chaney, Carnegie Inst. Wash. Pub. No. 346, 126-128, 1927.

<sup>2</sup> Newberry, U. S. Geol. Surv. Mon. 35, pl. 47, figs. 1-3, 1898.

smaller leaves show a certain resemblance to those of *Acer bolanderi* Lesquereux,<sup>1</sup> but there are many points of difference. *Acer lætum pliocenium* C. A. Mey, identified in the Meximieux tuffs by Saporta,<sup>2</sup> is very close to *A. scottiae* and the two may be identical.

The leaves and fruits occur together and are very similar to those of the living *Acer pictum* Thunb. (plate 11, figs. 5, 6; plate 12, fig. 2). The only other comparable species is *Acer platanoides* L., the undeveloped or immature leaves of which are like the fossil leaves.

The fruits are like those of *A. circinatum* Pursh, but the back of the samara is usually curved outward in this species.

*Acer pictum* grows in Manchuria, Japan and throughout China from the mountains of Kansu to the Pacific Coast.

This species is named in honor of Agnes Scott Train (Mrs. Percy Train).

Collection—Univ. Calif. Coll. Pal. Bot., Holotypes, No. 613; Paratypes, Nos. 614, 615, 616.

## ORDER RHAMNALES

### Family VITACEÆ

#### Genus VITIS Linné

#### *Vitis chaneyi* new species

(Plate 14, fig. 1)

*Description*—Leaf broadly ovate, indistinctly 3-angled in the upper half; length, 12 cm., maximum width, 11 cm.; apex acute (?); base cordate, with rounded open sinus; margin coarsely double serrate; petiole stout; leaf palmately 5-ribbed from the base, the lowest pair of primaries slender, nearly at right angles to the midrib, with 3 or more branching secondaries from the lower side craspedodrome to the marginal teeth; the inner pair of primaries well defined, craspedodrome to the marginal angles, with 6 or 7 secondaries on the under side craspedodrome to the marginal teeth; midrib regularly tapered to the apex; 8 pairs of opposite or subopposite secondaries, essentially parallel to the inner primaries, craspedodrome to the larger marginal teeth; tertiaries percurrent, nearly at right angles to the secondaries; bowed toward the margin; areolation, coarse polygonal; texture membranaceous.

The description is founded on two leaves of *Vitis* from the Trout Creek Formation and on a leaf of the same species from the Crooked River flora. The illustration is of the Crooked River leaf, since the Trout Creek material is less perfectly preserved.

The leaf bears a superficial resemblance to the leaves of *Platanus* and is very like the leaf figured by Newberry in Monograph 35 as *Platanus aspera*.<sup>3</sup> There can be no doubt of its identity with leaves of the genus *Vitis*. Its likeness with *Vitis leei* Knowlton or *Vitis inominata* Knowlton from the Raton Flora<sup>4</sup> is marked, although it differs from both species in its much larger size and in the finer marginal serrations. It is quite different from *Vitis hesperia*<sup>5</sup> Knowlton or *Vitis florissantella* Cockerell from the Florissant beds.<sup>6</sup> No leaves of *Vitis* have been reported from the Mascall or Bridge Creek localities, but Berry has figured a seed, *Vitis bonseri* Berry, from the Grand Coulee flora.<sup>7</sup>

<sup>1</sup> Lesquereux, Mus. Comp. Zool. Mem., vol. 6, No. 2, pl. 7, figs. 7-11, 1878.

<sup>2</sup> Archives du Muséum d'Histoire Naturelle de Lyon, Tome 1, 280, pl. 34, fig. 2-3, 1872.

<sup>3</sup> U. S. Geol. Surv. Mon. 35, pl. 42, figs. 1-3, 1898.

<sup>4</sup> U. S. Geol. Surv. Prof. Paper 101, pl. 67, fig. 4; pl. 107, fig. 1, 1918.

<sup>5</sup> U. S. Nat. Mus. Proc. vol. 51, pl. 26, fig. 4, 1916.

These leaves appear to be closer to the present *Vitis labrusca* L. than to any other of the living members of the genus. They are identical in the manner of placement of the primaries, number and spacing of the secondaries, marginal serrations and general shape. The living species is generally more deeply cordate than the fossil. Other similar species are *Vitis cordata* Michx., *Vitis cinerea* Engelm. and *Vitis davidii* Foex.

*Vitis labrusca* grows throughout the temperate regions of southeastern North America and eastern Asia. *Vitis cinerea* is found in the central and southern states and Mexico. *Vitis davidii* is a native of the temperate regions of eastern Asia. Species of *Vitis* are found in thickets along stream-banks, and their comparative rarity in the fossil record may be in part due to the fact that the leaves are not readily deciduous but tend to disintegrate on the branch.

*Occurrence*—Trout Creek Formation, Locality 275, 25 miles northeast of Denio, Oregon. The Gray Ranch, Crooked River Basin, 11 miles east of Post, Oregon, Locality 3749.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 620; Paratypes, Nos. 621, 622.

## ORDER ERICALES

### Family ERICACEÆ

#### Genus RHODODENDRON Linné

*Rhododendron* (?) sp.

(Plate 7, fig. 4)

*Description*—Leaves linear-lanceolate or strap-shaped; apex gradually narrowed to an acute point; base narrow-cuneate; length 8 to 20 cm., width 1.5 to 3 cm.; margin entire; petiole stout; midrib stout, tapered to a thread at the apex, somewhat flattened and with fine, longitudinal striations; numerous secondaries, 12 or more pairs, irregularly spaced at an average angle of 45° with the midrib, decurrent for a short distance along the midrib, ascending along the margin to loop with branches from the secondary next above, each secondary sending out from 1 to 3 branches near the margin which turn downward or form branching loops along the margin; tertiary venation made up of vague, irregular cross-ties; fine, reticulate areolation; texture coriaceous.

These leaves are too fragmentary to warrant a definite generic assignment. They bear a marked resemblance to the leaves of *Rhododendron*, particularly to those of some unnamed species in the University of California herbarium, collected in the mountains of southwestern China. The fossil leaves have a more slender apex, but in all other characters the correspondence is so close that they are tentatively placed in the genus.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 623.

#### Genus ARBUTUS Linné

*Arbutus traini* new species

(Plate 13, figs. 1, 2; plate 12, fig. 3)

*Arbutus* sp. Chaney, Carnegie Inst. Wash. Pub. No. 349, 36, 1925.

*Description*—Leaves oblong-lanceolate; length from 8 to 20 cm.; width 2 to 4 cm.; apex acute; base narrow-cuneate to rounded; margin entire, or dentate with forward-pointing saw-like teeth; petiole stout, from 2 to 5 cm.

long; midrib stout gradually tapered to the apex; secondaries numerous, irregular, straggling, and of variable size, making an angle with the midrib of about  $50^{\circ}$  near the base, which diminishes to about  $30^{\circ}$  apically; secondaries branching and anastomosing, lost in a reticulate network before reaching the margin; texture coriaceous.

Three forms of this genus have been reported from the Tertiary of the western states; *Arbutus matthesii* Chaney<sup>1</sup> from the Crooked River flora; *Arbutus* sp. Chaney<sup>2</sup> reported from several Mascall localities in Oregon, California and Nevada; and *Arbutus* sp. Dorf<sup>3</sup> from the Pliocene of the Santa Clara formation in California. The second of these forms is identical with the Trout Creek species. Berry has figured two leaves from the Latah flora<sup>4</sup> under *Apocynophyllum latahense*, which bear a strong resemblance to the Trout Creek *Arbutus*.

*Arbutus trainii* has many characters in common with the living *Arbutus menziesii* Pursh, showing the same type of venation and marginal variations, and is of the same average size; it differs from *A. menziesii* in having a larger percentage of lanceolate leaves with cuneate bases. It seems to be intermediate between *Arbutus xalapensis* H. B. K. and *Arbutus menziesii*, but occasional leaves occur which are longer than any that have been observed in either of these species.

There is a strong resemblance between the smaller lanceolate leaves and the leaves of *Photinia arbutifolia* Lindl. in shape, size and to a lesser extent in marginal characters, but the secondary venation of the fossil leaves does not correspond. *Photinia arbutifolia* has a smaller number of secondaries which are stouter and make a wide angle with the midrib, sending well-marked craspedodrome branches to the margin.

The center of distribution of the genus *Arbutus* is apparently in the mountains of northern Mexico, since at least seven species have been reported from that region. Standley is of the opinion that these may all be varietal rather than specific forms.<sup>5</sup> *Arbutus menziesii* has been reported from northern Lower California and is found in the mountains of southern California and throughout the California Coast Ranges from Monterey County north between altitudes of 300 and 4000 feet. It is also common in the Sierra Nevada north of Tuolumne County. The northern limit of its range is near Port San Juan on the British Columbia coast. It grows under a considerable range of temperature and rainfall. A shrub form is common in the California chaparral in districts where the annual rainfall may be as low as 25 inches, and northward in the humid Coast Ranges it is a good-sized branching tree on slopes where the annual rainfall may exceed 80 inches.

The madrone is one of the most characteristic trees of the west coast forests and, whatever its original source, a closely similar species has been a part of these forests since lower Miocene time. Leaves of this genus are not plentiful in the Crooked River flora, but appear in greater numbers in the upper Miocene floras. They are most abundant in the Trout Creek flora and in a fossil flora from volcanic tuffs of approximately the same age northeast of Ashland, Oregon. The specimens figured by Knowlton as

<sup>1</sup> Carnegie Inst. Wash. Pub. No. 346, pl. 20, figs. 1, 3, 4, 131, 1927.

<sup>2</sup> Carnegie Inst. Wash. Pub. No. 349, 36, 1925.

<sup>3</sup> Carnegie Inst. Wash. Pub. No. 412, 19, 1930.

<sup>4</sup> U. S. Geol. Surv. Prof. Paper 154-H, pl. 60, figs. 4, 7, 1929.

<sup>5</sup> Paul C. Standley, *Trees and Shrubs of Mexico*, U. S. Nat. Mus. Contr., vol. 23, part 4, 1099, 1924.

*Myrica lanceolata* and *M. idahoensis* from the Payette flora<sup>1</sup> may be a slender form of *Arbutus*.

This species is named in honor of Percy Train.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 624; Paratypes, Nos. 625, 626, 627.

## ORDER GENTIANALES

### Family APOCYNACEÆ

Genus APOCYNUM (Tournefort) Linné

*Apocynum indiana* new species

(Plate 12, fig. 1)

*Description*—Leaves oblong or oblong-lanceolate, base rounded, apex acute or obtuse; length 6 to 9 cm., width 2.5 to 4 cm.; margin entire; petiole slender, short, 1 cm. long; midrib, curving upward, camptodrome and looping with the next secondary above, sometimes with abaxial branches near the margin; tertiary venation reticulate, texture membranaceous.

*Apocynophyllum latakense* has been reported by Berry<sup>2</sup> from the Latah flora. The Trout Creek leaves are so similar to those of the common *Apocynum cannabinum* L. that they may be referred to that genus without hesitation. This living species is widely distributed in the United States and in Canada. In California it inhabits stream and river-banks from near sea-level to elevations of from 4000 to 7000 feet.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 628; Paratype, No. 629.

## ORDER GENTIANALES

### Family OLEACEÆ

Genus FRAXINUS (Tournefort) Linné

*Fraxinus* sp.

The characteristic seeds of *Fraxinus*, together with fragmentary leaves questionably referable to the genus, have been found occasionally in the leaf quarry. It may be the same species noted by Chaney<sup>3</sup> at the type locality of the Mascall flora. No definite species reference will be made until more material is assembled.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 630; Paratype, No. 631.

## ORDER ASCLEPIADALES

### Family ASCLEPIADACEÆ

Genus VINCETOXICUM Walt

*Vincetoxicum* (?) *trinervata* new species

(Plate 15, fig. 1)

*Description*—Leaves long-ovate, somewhat narrowed to a cordate base with rounded lobes; margin entire; length from 16 to 20 cm., width from 8 to 10 cm.; palmately 3 to 5 veined, the midvein much the strongest, flattened and finely ridged beneath, with a small cluster of glands at the junction of leaf blade and petiole on the upper surface of the leaf; the two inner

<sup>1</sup> Knowlton, 18th Ann. Rept. U. S. Geol. Surv. Part 3, pl. 99, figs. 5-7, 1898.

<sup>2</sup> Berry, U. S. Geol. Surv. Prof. Paper 154, 263, pl. 60, figs. 4, 7, 1928.

<sup>3</sup> Oral communication, Aug. 3, 1932.



primaries slender, leaving the midrib at an angle of  $25^{\circ}$ , ascending over half the length of the leaf and forming anastomosing loops along the margin with branching secondaries from the midrib; basal primaries, when present, attenuate and irregular, nearly at right angles with the midrib, divided into branching loops along the margin; 4 or more secondaries branch from the outer side of the inner primaries and form anastomosing loops along the margin; tertiary venation reticulate, but poorly defined and irregular; texture succulent.

These impressions are assigned to the genus *Vincetoxicum* with some hesitation, although the similarities are marked. The modern range of the genus is largely in subtropical or tropical America, and this distribution is not in keeping with the cool, temperate character of the fossil flora.

The leaves are herbaceous in character and with a succulent rather than a coriaceous texture. The cluster of small glands at the base of the leaf, the well-defined palmate venation and the looping of the secondaries along the margin are all distinguishing characters of *Vincetoxicum*. In size, the fossil leaf is most similar to *Vincetoxicum magnifolium* (Pittier) Standl. which grows in the forests of Oaxaca, but this species has leaves which are usually more rounded than the fossil leaves. The general shape and venation of the fossil leaves are like the leaves of several species which are found in northern Mexico and the southwestern states such as *V. pilosum* (Benth.) Standl., *V. reticulatum* (Engelm.) Heller, and *V. diadematum* (Edwards) Standl. *V. carolinensis* R. Br. and *V. obliquus* (Jacq.) Britton are natives of the eastern and south-central states.

The members of the genus are perennial, twining, herbaceous or woody vines, which grow along stream-banks or in moist thickets.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 632; Paratype, No. 633.

## ORDER ASTERALES

### Family COMPOSITÆ

#### Tribe CYNAREÆ, Engler and Gilg.

##### Genus SAUSSUREA DC.

*Saussurea* (?) sp.

(Plate 16, fig. 1)

This genus is represented by an impression, and its counterpart, of a nearly complete leaf and petiole.

*Description*—Leaf linear-oblong, with slight decrease in width from base to near the apex; length about 15 cm., width in the median portion 4.5 cm.; base, rounded auriculate; apex not preserved but evidently acute; margin sinuate-dentate; petiole stout, 5 cm. long; midrib, tapered to the apex, slightly irregular as to course, marked by irregular longitudinal ridges which branch to the secondaries; secondaries irregularly spaced, unequal in size and at various angles with the midrib, the two lower secondaries curve downward into the ears, the next succeeding pair arise from nearly the same point of attachment and branch upward at angles of  $35^{\circ}$  and  $40^{\circ}$ , the remaining secondaries leave the midrib at angles of from  $40^{\circ}$  to  $70^{\circ}$ ; secondaries branching and anastomosing, tertiaries near the margin craspedodrome to the teeth; tertiary venation reticulate; areolation coarse and irregular, texture heavy membranaceous.

The texture, irregular venation, sinuate-dentate margin and auriculate base are best matched by certain species of the Compositæ, although it differs in minor details from all the herbarium specimens examined. It is closest to the genus *Saussurea*, one species of which, *S. americana* Eaton, grows on the western slopes of the Cascades in moist places from 6000 to 7000 feet. The leaves of *S. discolor* DC., found in the mountains of northern Mexico, are closely similar to those of the fossil species except for size. The fossil leaves also resemble the leaves of *Adenocaulon bicolor* Hook. whose habitat is also in the Cascade Mountains, but this latter species has broader, more ovate leaves than the fossil specimen. Some of the species of *Eriogonum*, particularly *E. grande* Jepson and *E. compositum* Dougl., have a similar outline and venation but lack the dentate margin.

The genus *Saussurea* is widespread in the northern hemisphere; it has been reported from the Altai region, the Himalaya Mountains, eastern Asia, Europe, and North America from Alaska to Mexico.

*Collection*—Univ. Calif. Coll. Pal. Bot., Holotype, No. 634; Paratype, No. 635.

### INCERTÆ SEDIS

#### *Phyllites oregonianus* Knowlton

(Plate 7, fig. 2)

*Phyllites oregonianus*, Knowlton, U. S. Geol. Surv. Bull. 204, 85, pl. 16, fig. 1, 4, 1902.

*Description*—Leaves lanceolate, about equally narrowed to apex and base; length from 10 to 12 cm., width from 1.8 to 2.4 cm.; apex acute; base cuneate; margin entire; petioles short, not longer than 0.6 mm.; rather slender; midrib well defined at the base but gradually tapered and becoming very thin near the apex; secondaries about six pairs, usually very thin and obscure or sometimes entirely wanting, rising at an acute angle, 15° to 20°, and ascending, with a rather sinuous course, for a long distance along the margin, camptodrome; tertiaries indistinct, usually nearly parallel with the midrib but with a few cross-ties at right angles to the secondaries; no areolation preserved; surface of the impression marked by minute rounded depressions; texture heavy; but not coriaceous.

These leaves appear to be identical with *Phyllites oregonianus* Knowlton and *Phyllites personatus* Kn. from the Bridge Creek flora. The resemblance to the former species is especially close.

The impressions are clearly from the leaves of some herbaceous plant. They are like certain species of *Coreopsis* which inhabit wet ground or some of the species of *Valeriana*. The resemblance to leaves of *Coreopsis* is closer than to leaves of any other of the species with which these impressions were compared but it is not close enough to warrant placing them definitely in that genus.

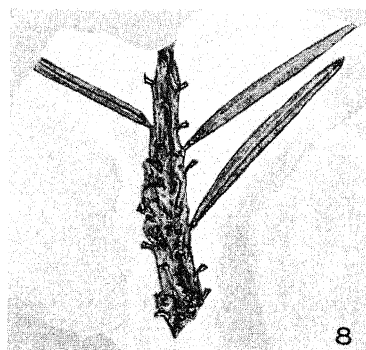
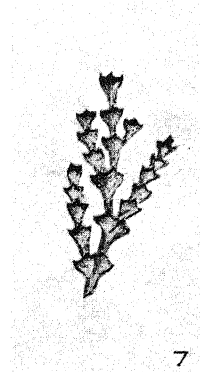
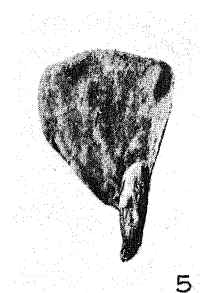
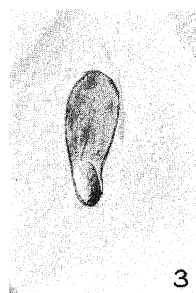
The venation and general character of the leaves is well matched by *Polygonum exsertum* Small, although the fossil leaves are much larger. They are closer in general shape and size to *Polygonum bistortoides* Pursh but lack the long petiole and the peculiar venation characters of that species. The secondary venation resembles that of certain species of *Lathyrus*, but the presence of a petiole makes it possible to definitely eliminate that genus.

*Collection*—Univ. Calif. Coll. Pal. Bot., Plesiotype, No. 636; No. 637.

PLATES 3 TO 16

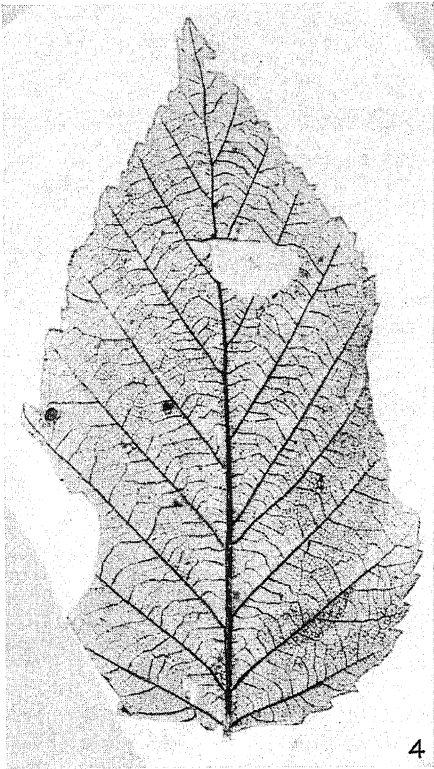
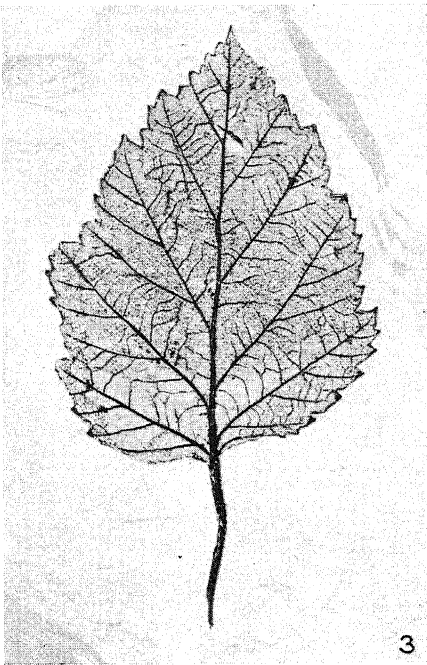
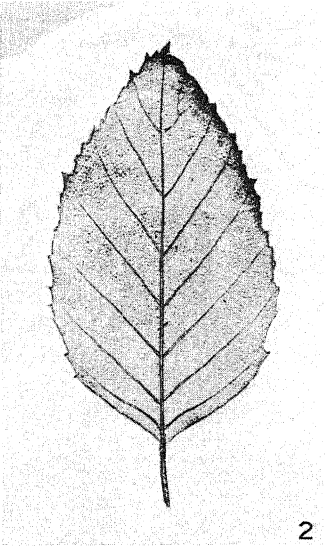
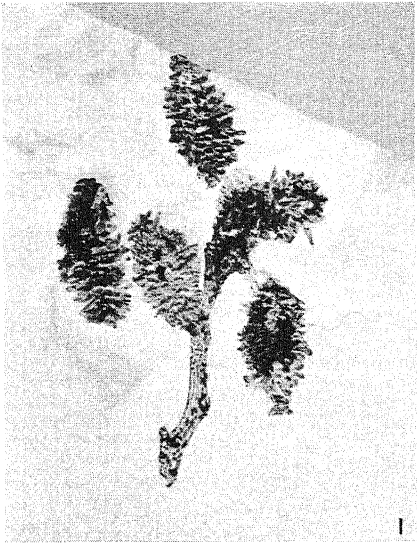
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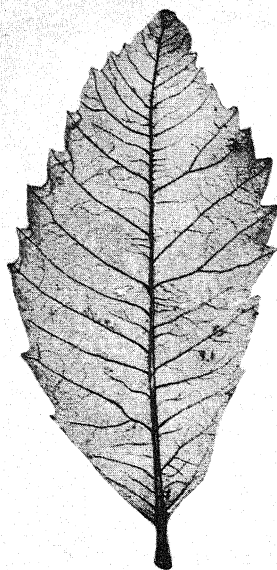
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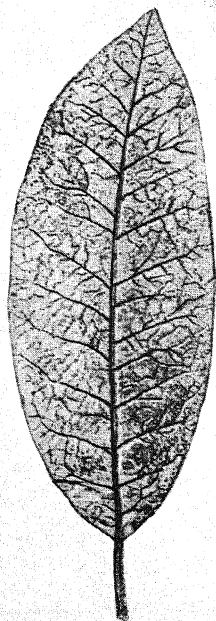
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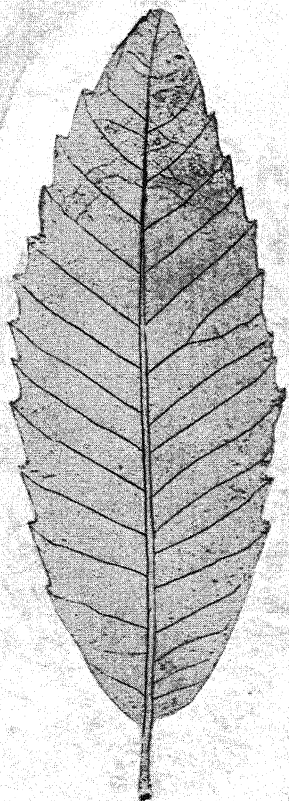




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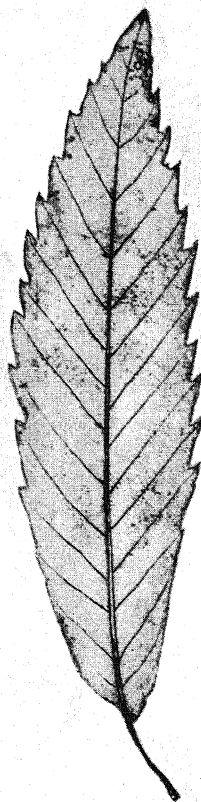
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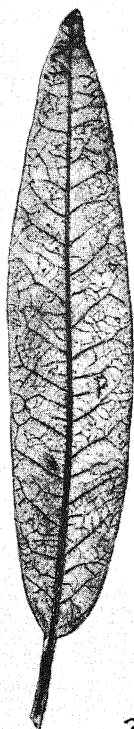
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# DESCRIPTION OF PLATE 6

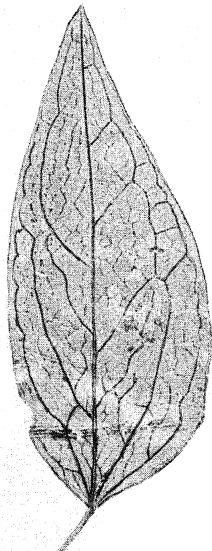
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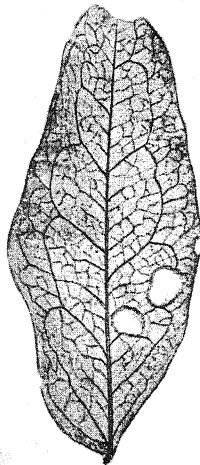
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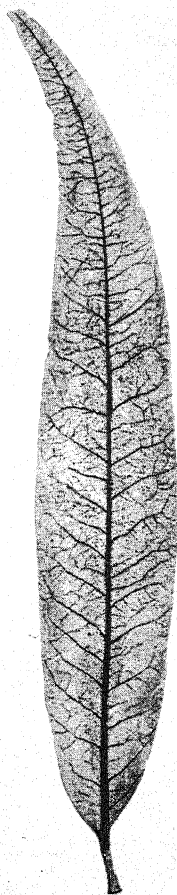
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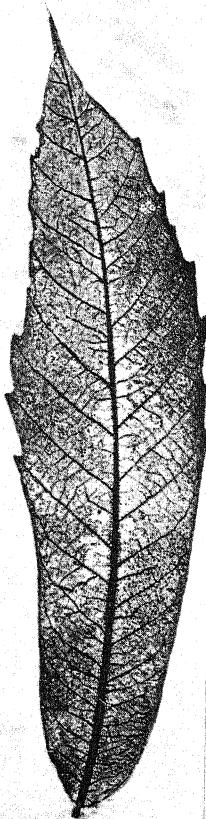
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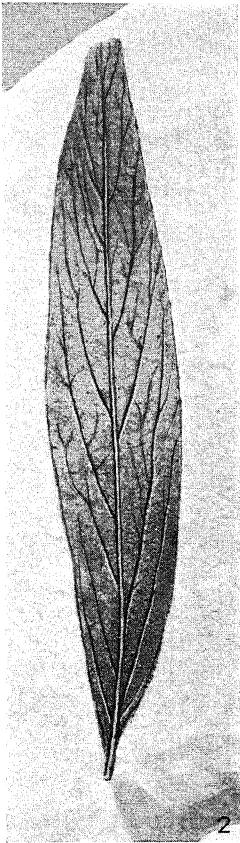


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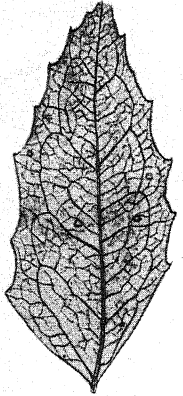
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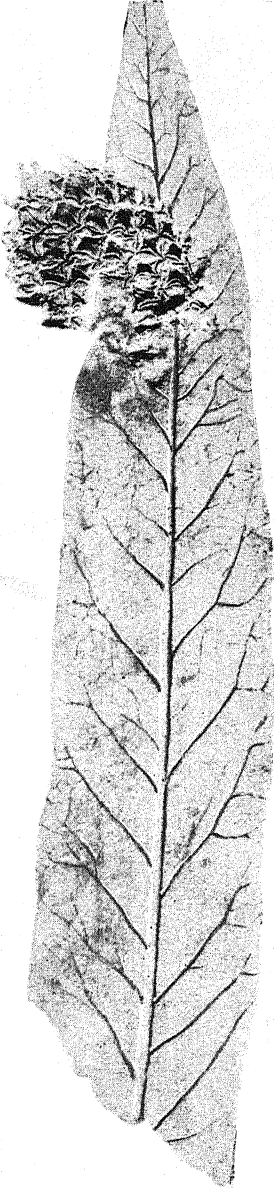
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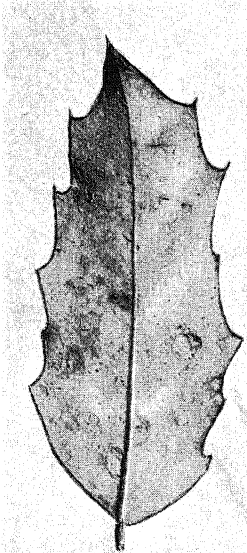
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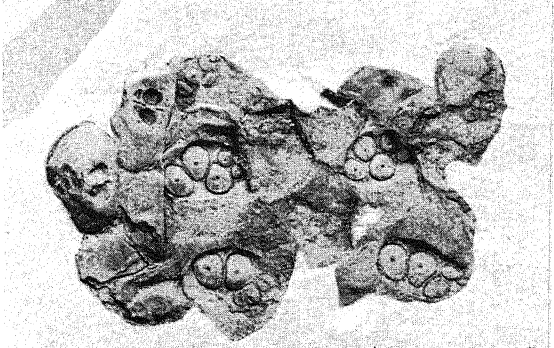
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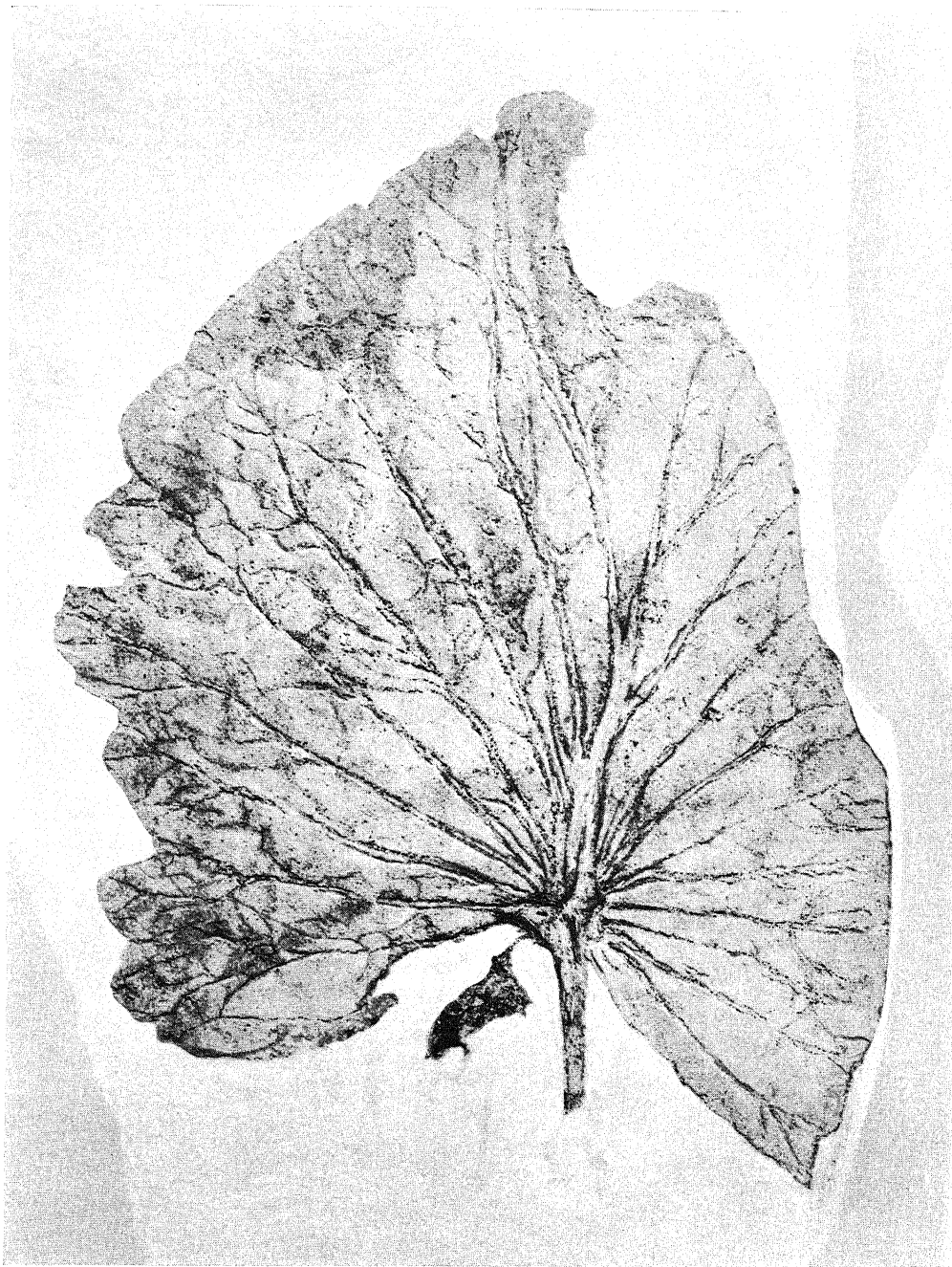
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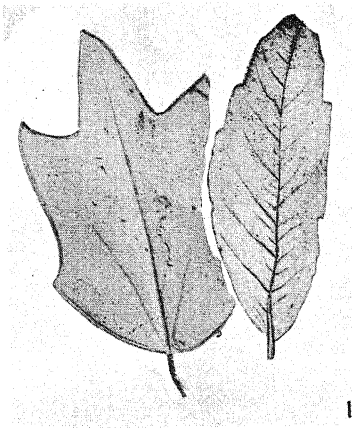
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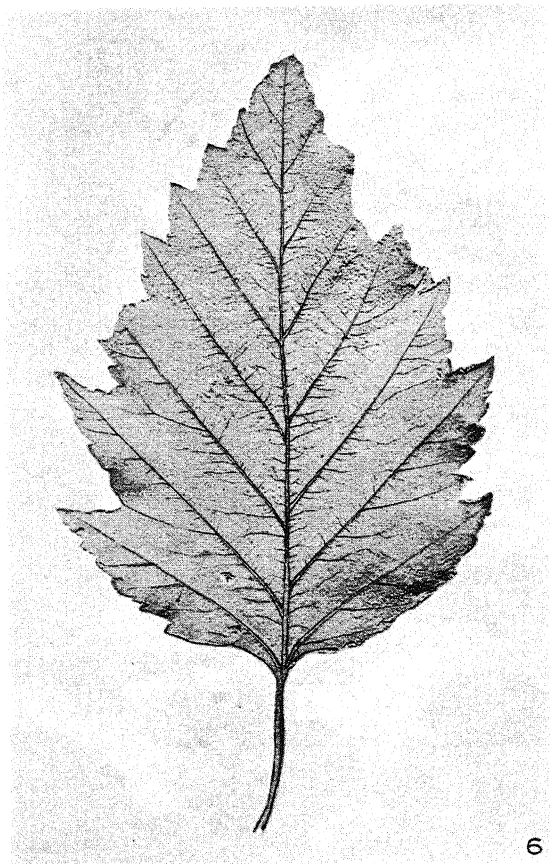
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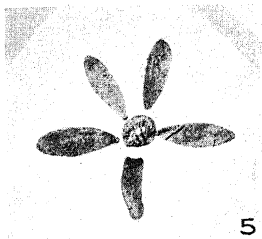
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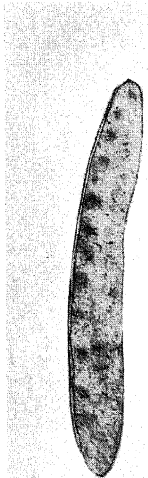
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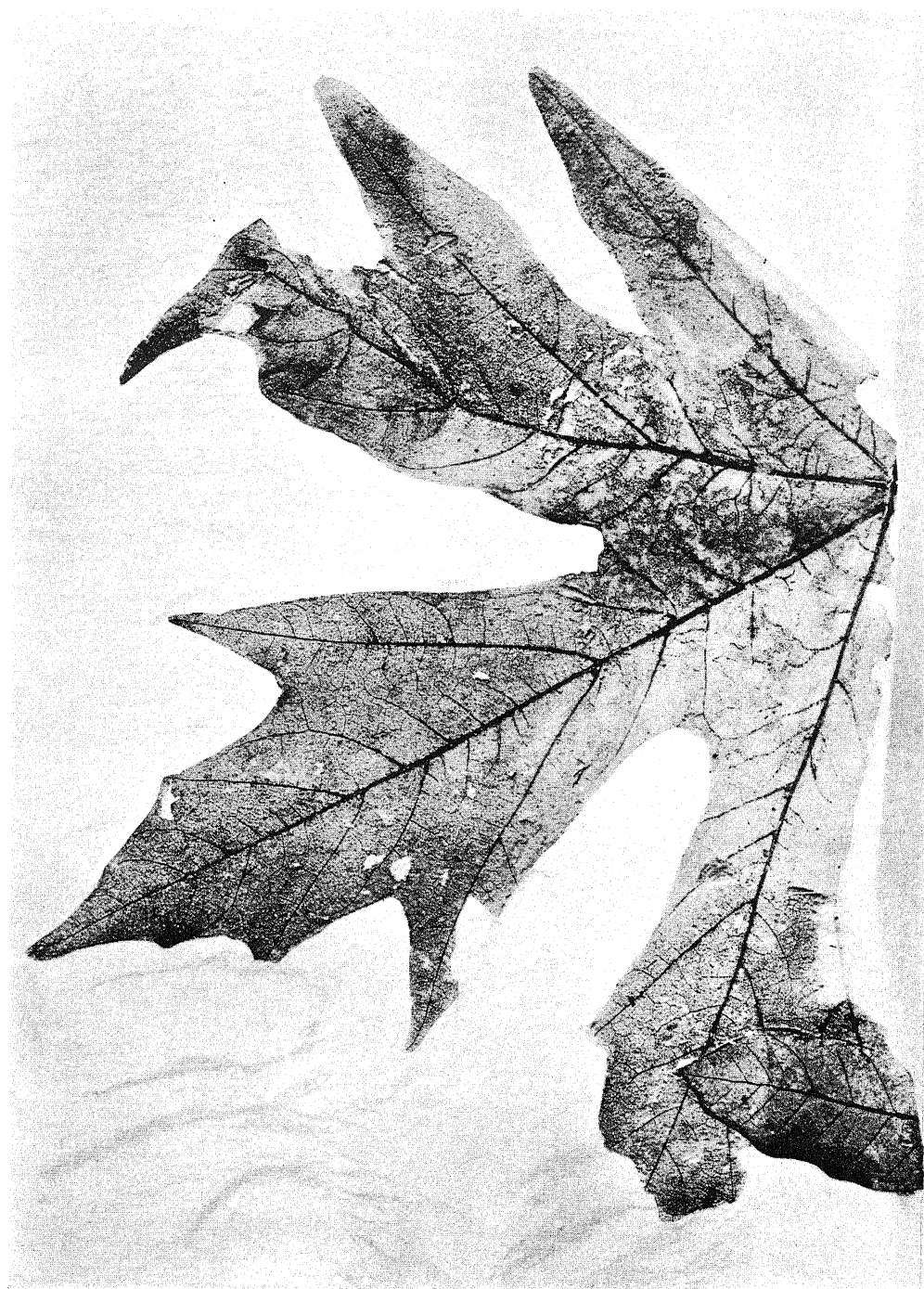


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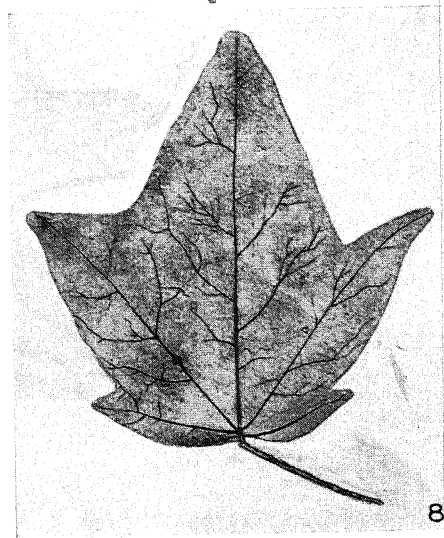
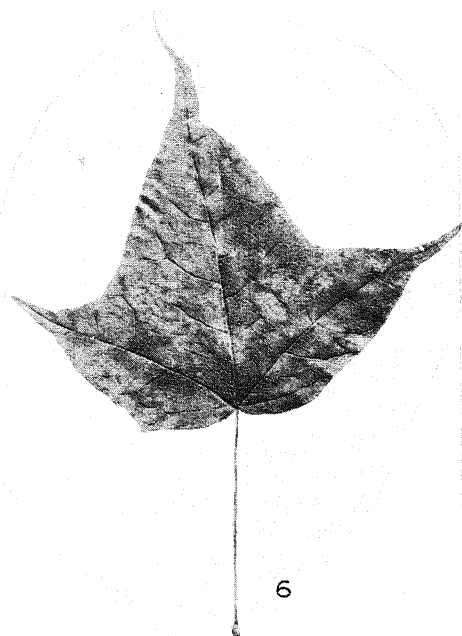
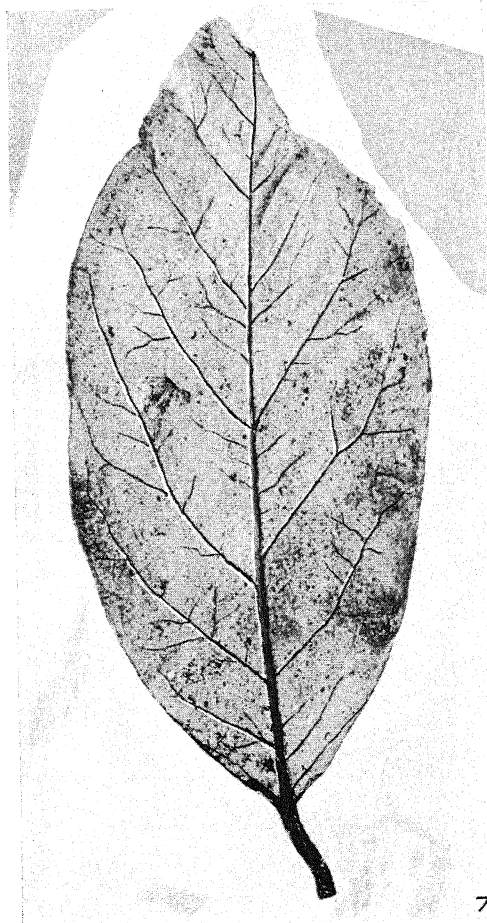
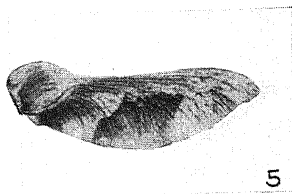
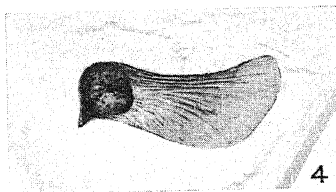
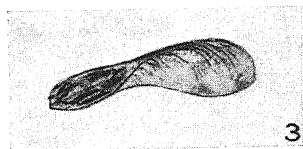
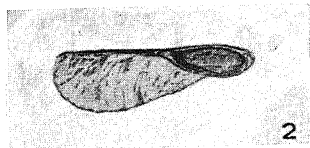
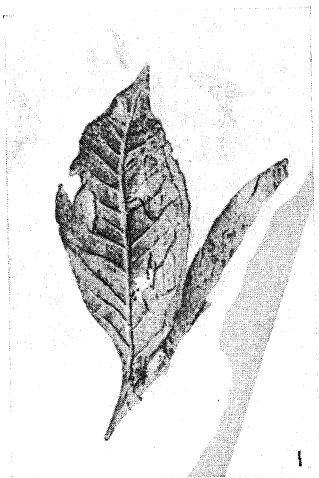
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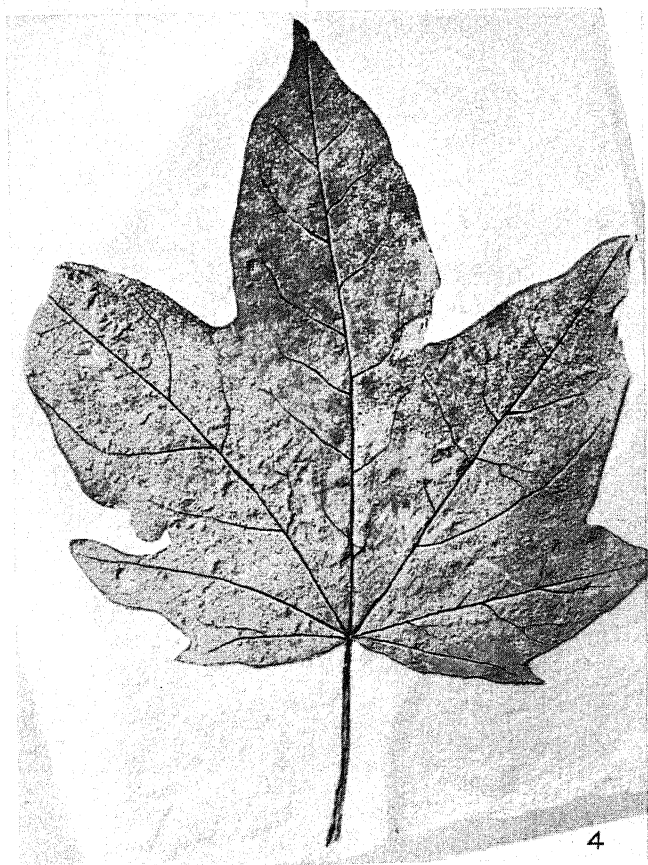
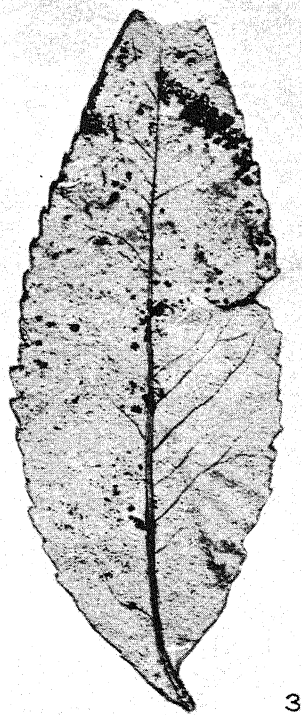
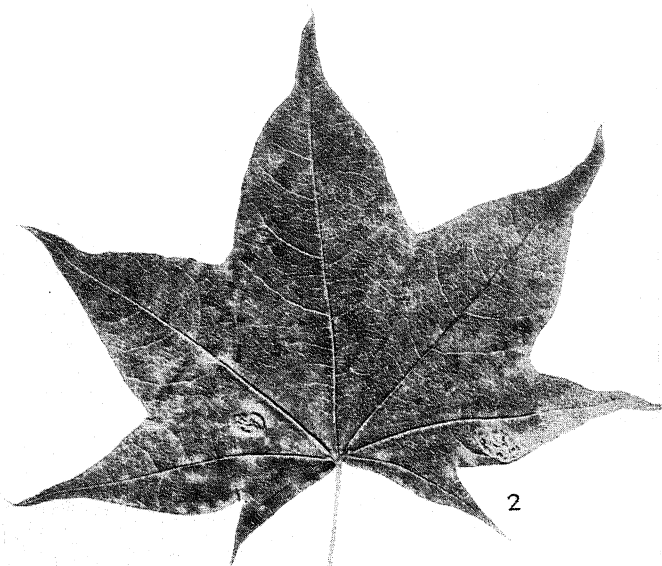
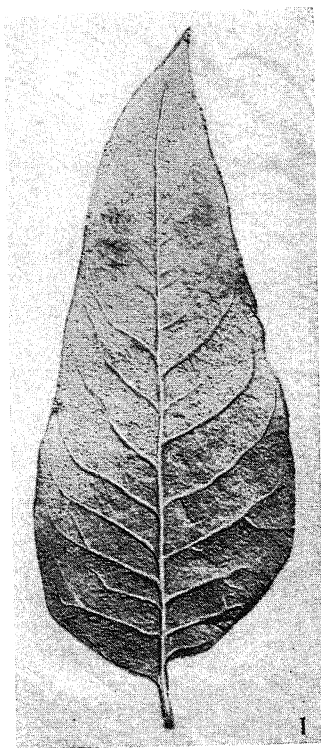
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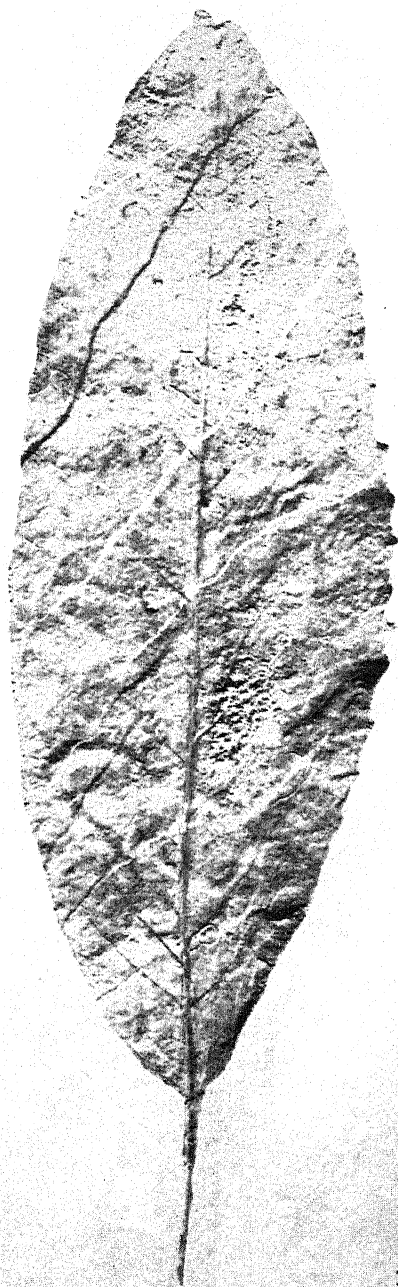
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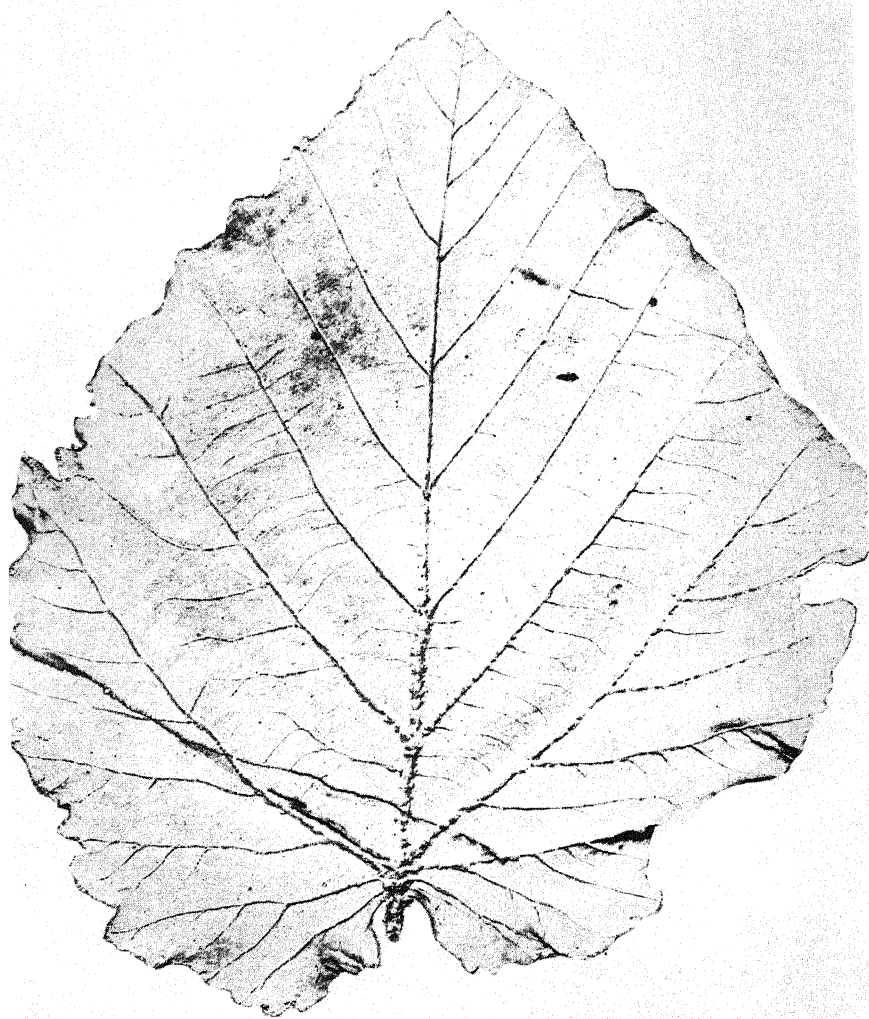
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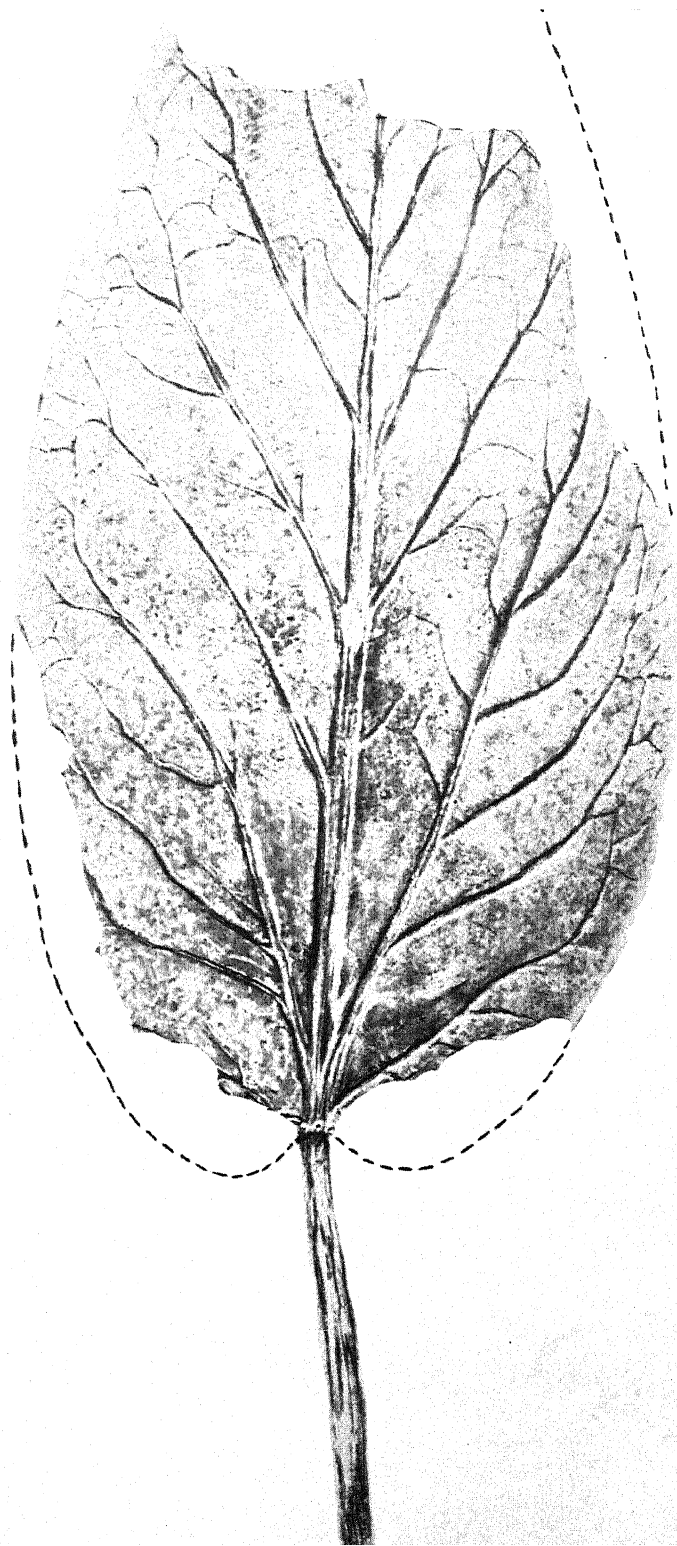
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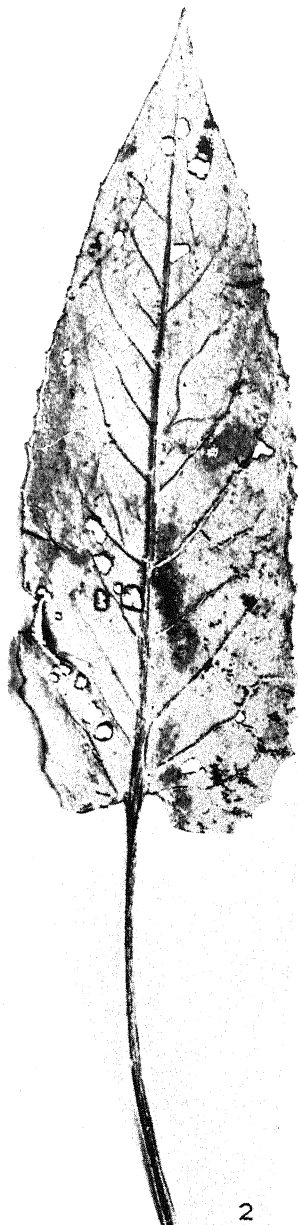


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